The Gustafson's Spherical TVRO Antenna Manual

You can now build a twelve-foot spherical antenna with no special tools, without touching pen to paper and at a cost of less than $300. This manual authored by Mike Gustafson, also contains formulas for building the same antenna in a 6-meter or 20-foot size.

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STT'S SPHERICAL MANUAL
THE GUSTAFSON SPHERICAL TVRO ANTENNA MANUAL

. . . a Manual to allow you to build your own 12-foot spherical antenna utilizing lumber and screen wire, for less than $300. As the author, Mike Gustafson describes the goal: "The concept behind this new spherical antenna was that it has to be easy to build, not require any mathematics and not cost an arm and a leg. Oh yes, I forgot, it had to work great, as well!"

Mike L. Gustafson, the author, founded Satellite Receiving Systems in San Jose, CA, in 1981 as a natural outgrowth of fifteen years of work in the microwave industry. This company specializes in complete earth station integration, technical consulting, training and education, and new product evaluation.

Prior to starting S.R.S., Mike worked for a number of microwave companies in satellite communications field. His experience ranges from TVRO development back in 1976 to managing an uplink to Satcom and Westar 4 today.

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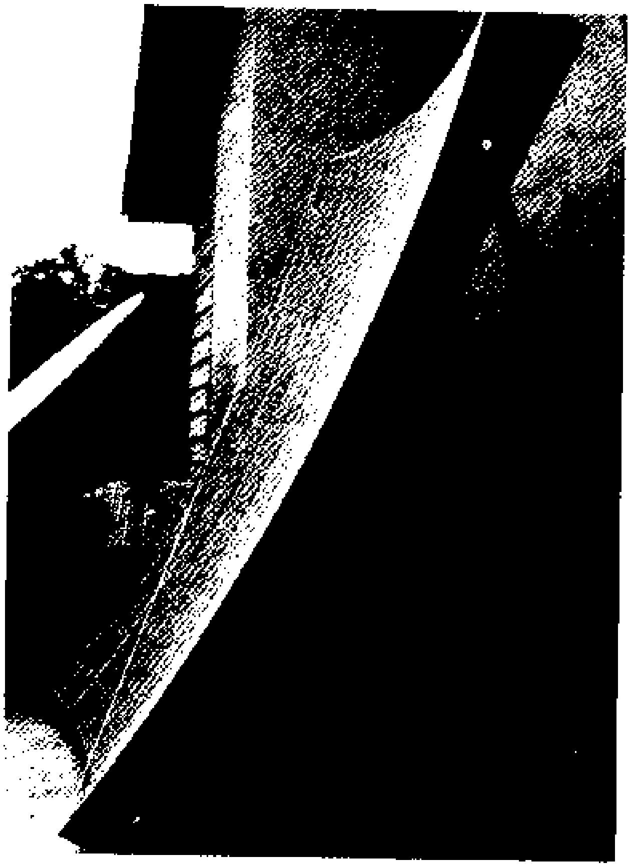
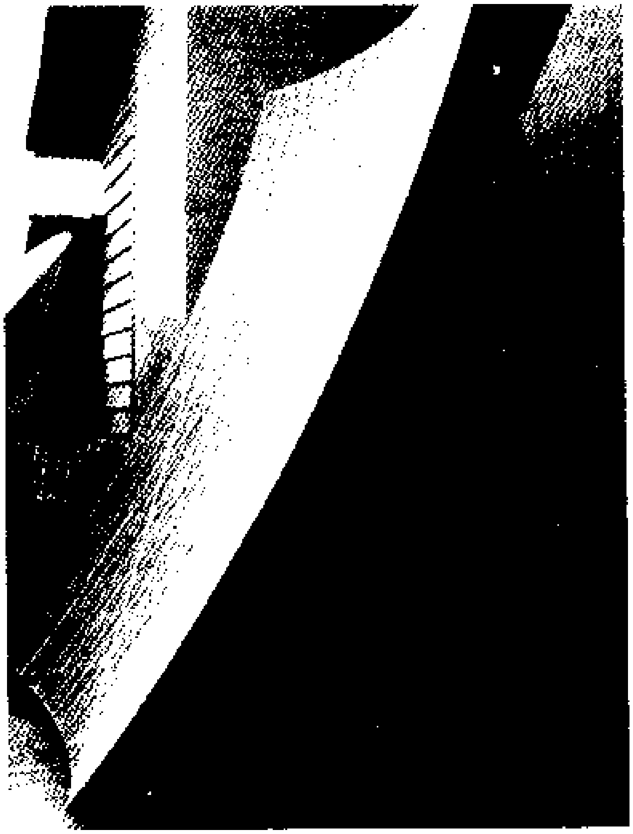


Every spherical antenna designer owes a great debt to the early work of the spherical antenna pioneer Oliver Swan. He did more to bring this antenna technology into common use than any other single contributor.

There are a number of people who greatly assisted me in the design and construction of this antenna and the development of this manual. First, I would like to thank my wife Linda for her unflagging good nature and assistance in the construction of the antenna. She was my best critic as I wrote this manual as well. Second, I would like to thank my boss Dr. Rolf Dyce for editing the math section of this manual and giving me a little slack time to work on this project. Last, but not least, I would like to thank Ray and Linda Maxfield, WA6VAB and N6EIW. Ray for his helpful suggestions during the design of the antenna and Ray and Linda both for coming over for a barbeque and then finding out they had to help raise the antenna.

1.0) INTRODUCTION.



The purpose behind designing this antenna and writing this manual is to provide the T.V.R.O. enthusiast with an inexpensive alternative to the high cost antennas currently available. If you live in a place where it is difficult, or impossible to import large antennas, then this manual gives you the opportunity to have first rate video by building the antenna yourself. All that aside, there are some people who would rather build something themselves than purchase it. This last group of people is the one that I relate to best and for whom this manual was really written.

My basic premise when I started to design this antenna was to come up with something that was easy to build and didn't cost an arm and a leg to buy the material. The antenna had to be built using the most basic hand tools, would require absolutely no mathematics, and when finished, had to provde sparkle free pictures.

The manual had to provide all the information required to build the different parts of the antenna system, all the information needed to find the satellite, and direction on how to fine tune the antenna for the best signal.

This manual then is a stand-alone source of information for the complete understanding and construction of a antenna system capable of operating with any electronics system.

There are other manuals that will cover some of the same information I do, and they will do it in more detail. I have provided all the information you need to get your antenna system up and running. If you are interested in detailed information on satellite mechanics, I would recommend Steve Gibson's Satellite Navigator manual, published by S.T.T.I.

I tried to keep track of the amount of time required to construct this antenna. Keep in mind that I started and stopped a million times to solve all the little problems you run into when doing a project like this. I hope that means that you won't run into the same problems I did.

With that in mind, I figure it should take someone with no talent in wood working, like me, about 40 hours or less to construct this antenna. My notes indicate that I only used 32 hours to construct the antenna, and the other 8 hours were used building the feedhorn and its brackets and stand. The amount of money spent on materials for the antenna was $300.00 with another $50.00 spent on the feedhorn and stand.

The construction of this antenna is not difficult or tricky, just tedious. I had to keep reminding myself of all the great pictures I was going to see when I got the antenna done. If you take it a step at a time, and don't worry about what is coming up next, the job will not seem as formidable.

I have broken the whole project down into small steps so you can do a little bit after work each day. If you do that you will never have to work very hard and yet at the end of a couple of weeks the antenna will be ready to turn on.

I will make one last suggestion. Please, please read the whole manual cover to cover at least once before lifting a finger to build it. Doing this will give you some idea where we are going and if you want to order some of the parts rather than build them you can get them on order.

I set out to build a 12 foot antenna because, for all the continental U.S., that is large enough for sparkle free pictures. I realized also that for whatever the reason, there are those people that would require a larger antenna. So, using all the same techniques, I have included a section that describes how to build antennas up to 20 feet across.

When I started this project I decided that I wouldn't touch fingers to keyboard until the antenna was completed and it worked properly. If I got to the end, and the antenna only worked so-so, I was going to take a chain saw to it and forget the whole thing. The day I first turned it on I had a bunch of friends over to help me raise the antenna. I was going to stall around until they all left before looking at the pictures. They, of course, were having none of that!! So I was forced to show the first pictures to a gallery of people. If they were bad, I would not be able to steal quietly away and forget the whole thing. As I tuned the receiver from transponder to transponder I was amazed to see absolutely snow-free pictures. I was elated, but at the same time sad, that meant I would have to write this manual. That job took longer than building the antenna.

AZIMUTH - Degrees clockwise from true north as measured by compass direction. To find true north, sight the start Polaris at night or apply a local correction for a magnetic deviation to your compass reading.

AZIMUTH-ELEVATION MOUNT - Aiming system antenna mount for a moveable dish. It is a two pivot system changing azimuth angle from due north and elevation above the horizon.

C/N CARRIER TO NOISE RATIO - Ratio of carrier level to noise level measured in decibels. The better the C/N, the better the S/N and quality of the TV picture. Eleven dB and above is excellent, greater than 7 dB is good. less than 7 dB the picture quickly deteriorates into noise.

COMMERCIAL TVRO - A system that supplies programming for sale through a MATV or CATV system. Includes a commercial quality dish, usually 3 5 to 5 meters, an LNA with a good noise temperature with a long MTBF (Mean Time Between Failures). A low distortion receiver and a high quality modulator operational at a 3 dB margin. Above the receiver's FM threshold complete the system

DOWN CONVERSION - Typically a conversion of 3.7-4.2 GHz microwave signal to a VHF frequency of 70 MHz. Signal processing components become a great deal less expensive.

EIRP - Effective isotropic radiated power. A satellite TV signal's relative strength expressed in dBw. From a peak of 37 dBw at boresight in the midwest to a low of 30 dB in Florida. At 34 dBw and above, home reception becomes much less expensive.

ELEVATION - Degrees above the horizon. Zero degrees indicates horizon and 90 degrees is directly overhead. Indicates an aiming angle to a TV satellite

F/D - Focal length of diameter ratio. Varies with each antenna. The higher the ratio the higher the apeture efficiency but may be more susceptible to sidelobe noise.

FREQUENCY COORDINATION - A computerized service using a U.S. data-base to resolve existing or potential conflicts between users of the 4 GHz microwave band. i.e. Bell telephone long line uses 4 GHz towers throughout the U.S.A. A TVRO and telephone transmitter looking at each other may cause jamming without proper shielding

GHz-GIGAHERTZ - Abbreviation for billions of cycles per second. 3.7 to 4.2 is the U.S. frequency band allocated for satellite TV

LOOK ANGLE - Elevation of antenna from horizon, as in aiming a given antenna at a CATV satellite. Important consideration for possible sight obstructions

ORTHOMODE COUPLER - A section of waveguide. Horizontal linear and vertical linear satellite TV programming can be received simultaneously through two LNA's "coupled" at right angles

PARABOLIC DISH - A rounded dish (made of many materials) covered with a metal reflective surface and accurate as a perfect parabola to within 0.1 inch. Focuses all microwave energy at a single point.

POLAR MOUNT - Much easier to aim than azimuth elevation mount. Look angle is positioned one time only. The other pivot is set to sweep the satellite arc. Fine adjustments may be required.

POLARIZATION - Both horizontally and vertically polarized frequencies are available from a CATV satellite. These frequencies overlap in order to increase TV satellite capacity. Polarizations on the satellite and the dish must match or signal will be lost.

ROTOR SYSTEMS - A motorized means of rotating an LNA feed 90° to get from horizontal to vertical polarization. Can be done remotely.

S/N SIGNAL TO NOISE RATIO - Quality expressed in dB in a TVRO picture. 50 dB signal to noise is superior to a broadcast studio, 45 to 50 dB for a CATV system, 45 dB for a VTR system. 40 dB signal to noise is a watchable picture. Forty five dB signal to noise is produced in a TVRO when the C/N is 8 dB above the FM threshold

SPARKLES - Caused by weak signal and appear as streak or dot interference in a satellite TV picture. Can be caused by an FM video demodulator not locking up. Tearing or loss of picture can occur in extreme cases

SPHERICAL ANTENNA - Alternative form of dish antenna. Has a circular cross section instead of parabolic. Can employ multiple feed horns to receive signals from up to 10 satellites at once. Can encompass a 40 degree orbital ARC. Oliver Swan was its designer

TRANSPONDER - A channel implemented with satellite hardware. TV satellites have 12 or 24 transponders

TVRO - Television Receive Only - An antenna, LNA and receiver. Same as an earth station or satellite TV receiver

UPLINK - The transmitting earth station as opposed to the receive only earth station

WAVEGUIDE - Prevents signal loss with the use of a microwave conductor in the shape of a rectangular tube

WINDLOADING - The amount of wind pressure a dish can sustain. Minimum 40 MPH without damaging picture quality and up to 120 MPH peak.

2.0) SPHERICAL Vs PARABOLIC ANTENNAS.

There are two different kinds of antennas currently in use in the satellite TV world. The most widely known is the parabolic, which is the so called "dish" shaped antenna. Photo 2.1 shows a couple of different sizes of parbolics. The one on my right is a 4 foot model and the one on my left is a 10 footer. They both are quite deep in that they would hold a lot of water. In fact, you could make a spa out of the big one if you got tired of all the video they bring in. I use both of these antennas for video reception, they each look at a different satellite.

The other type of antenna in widespread use is the spherical antenna. Photo 2.2 shows the 12 foot spherical I built for this manual. If you compare both photos you will see that the parbolic is very deep and the spherical is quite shallow. This means the F/D (focal point divided by diameter) is different. All that means is that the feedhorn is further away from the spherical than it is from the parabolic. The focal point of the parabolic is 3 feet from the center of the antenna and the focal point of the spherical is 15 feet from the center of it. So the focal point divided by the diamter (F/D) of the parabolic is .3, and the F/D of the spherical is 1.25. Some of you are now saying that a spherical doesn't have a focal point; rather, it has a focal line. You're right, but for the sake of this manual I am going to call it a focal point

There are two main disadvantages with the spherical. One, since the focal point is 15 feet in front of the antenna, the amount of ground required to install one is quite large, 12 feet by 28 feet. Two, trying to move a spherical around to receive other satellites requires a crew of 4 people

There are a lot of advantages to a spherical antenna. We don't have to move them around to receive other satellites. In the next section you will see that it is possible to view 4 to 6 satellites by just moving the focal point structure around and not touch the antenna. You can also receive multiple satellites at the same time. Just stand up more focal point systems in front of the antenna at the correct spot and you have another satellite. Because a spherical antenna is a section out of a circle it is a lot easier and cheaper to build one. Most sphericals are covered with a open mesh type screening so the wind loading is a lot less than a parabolic with a solid surface

If we were to compare a parabolic and a spherical antenna of the same size and same F/D we would find that the curve of both antennas would be the same within 70 thousandths of an inch. We would also notice that the performance of both antennas would be the same. Size for size, you will get the same high quality picture from the spherical as you would from a parabolic. The biggest difference between the two types of antennas is cost and convenience. The parabolic antenna can be motorized so you can, from your easy chair, run the dish from satellite to satellite. The cost to do this is still quite high between $1,00 and

PHOTO 2.1

$1,400. If you would like to build your own antenna and save a lot of money then a spherical is the only way to go. Parabolics are quite hard to build due to the curve you must hold. A spherical is nothing more than a section out of a very large circle so the curve is very easy to hold and to check.

That brings me to the next point I need to cover, how accurate do you have to be to have a good operating antenna? The length of the electrical signal as transmitted from the satellite, called wavelength, is 2.989 inches. Any bumps or discontinuities in the reflecting surface of the antenna has to be smaller than 2.989 inches. How much smaller? In order for this antenna to give you sparkle free pictures you should hold the surface curve to between 1/10th and 1/20th wavelength. This works out to be between 1/4 and 1/8 inch. I found that I could hold 1/4 inch easily and most of the time I was able to hold the curve to 1/8 inch or less. The smaller your errors are on the curve means the better the pictures will be.

I chose wood as the construction medium because it appeared to be the easiest and cheapest material to get. This was the first woodworking project I have tried since high school, so I don't have any particular talent in this field. I guess what I am trying to say is, if I can do it, you can do it. If you happen to know a hand plane from an airplane then you're home free. If you work through each section one at a time, you will get to the end of the manual with a completed, well operating, antenna. You will also have the pride of having done it yourself, and saved a bundle of money.

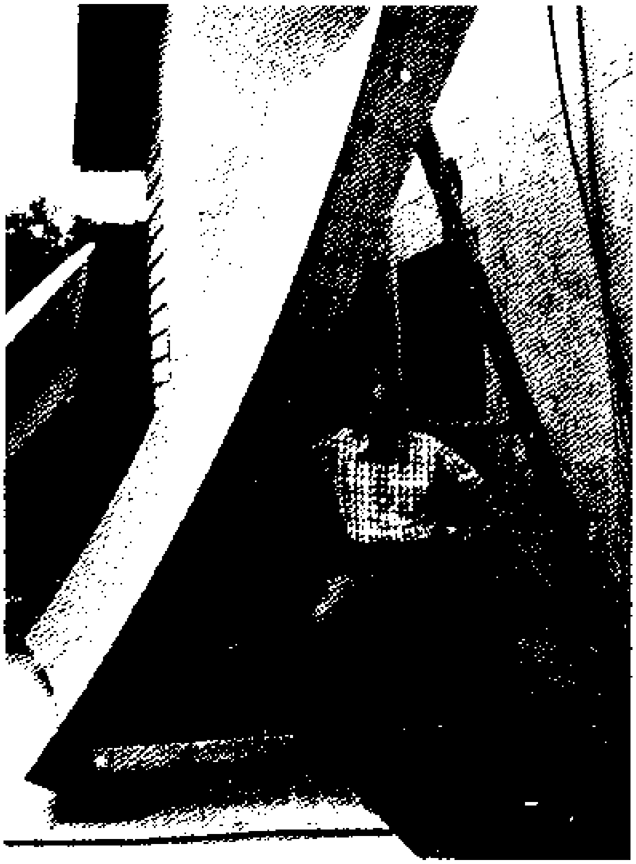


PHOTO 2.2

3.0) ARE THE SATELLITES VISIBLE FROM YOUR LOCATION?

Before we lift a finger to build this antenna we better figure out which satellites, if any, we will be able to view. All of the geostationary satellites are on what is called the Clarke Belt, named after the science fiction writer, Arthur C. Clarke, who first conceived the idea of man-made satellites orbiting the earth.

He figured that if a satellite was far enough out in space you would only need three of them to cover the earth. He was close, but he didn't count on "Big Business" and competition. Consequently, we now have about 59 satellites in fixed orbit around the earth. From most of the continental U.S. you can "see" about 19 or 20 of them. If you put an object into orbit at 22,300 miles directly out from the equator, at the proper speed, that object will appear to stop moving in relation to the earth. That's good because otherwise, we would have to have tracking antennas and those are quite expensive. So, thanks to the laws of physics, we can point our non-tracking antennas at a satellite and come back a week or month later and the satellite will still be there. So, of course, the question is how many of them can you see from your location?

The broadcast frequency of the satellites is from 3.700 GHz to 4.200 GHz. These frequencies do not travel around corners or bend and they are very easily absorbed by trees, houses, people, or just about whatever it is that is between your antenna and the satellite. We must therefore have a pretty clear view to that point in the sky where we think the satellite is parked.

In a old house I used to live in, my look angle to Satcom 3 was through the top of a tree and power pole. During the winter my pictures were great, but come spring the tree would get its leaves and the picture would degrade. It was still a good picture, but I knew it could be better. I finally got permission from the owner to cut the top 5 feet of the tree off. Problem solved! My point in all this is pick carefully where you want to plant this antenna.

With this manual I have included a bunch of look angle charts that cover all the satellites for 22 locations around the U.S. Try to pick the chart that is the closest to your location. If none are close enough, that would be about 100 to 200 miles, then I have also included a list of look angles for Satcom 3 and Westar 4 for

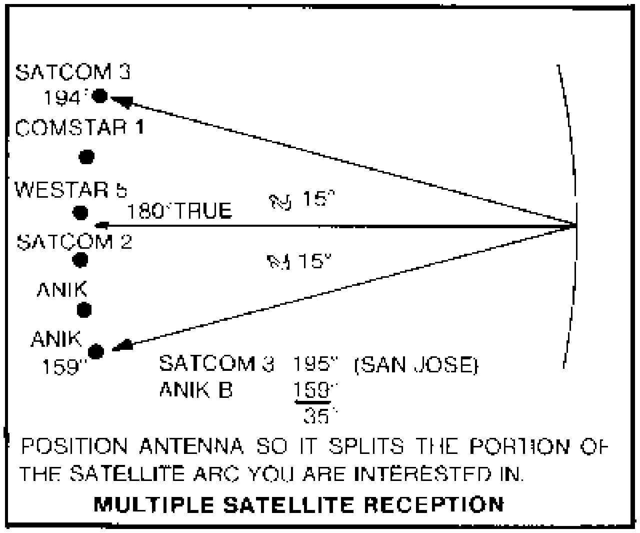

SATCOM 3
194°
COMSTAR 1
WESTAR 5
180°TRUE
≈ 15°
SATCOM 2
≈ 15°
ANIK
ANIK
159°
SATCOM 3 195° (SAN JOSE)
ANIK B 159°
35°
POSITION ANTENNA SO IT SPLITS THE PORTION OF THE SATELLITE ARC YOU ARE INTERESTED IN.
MULTIPLE SATELLITE RECEPTION

FIGURE 3.1

every state in the union. The longitude and latitude for the center of the state was used to generate these numbers. Thank God for "calculatin engines", and Steve Gibson.

All the charts read basically the same way. The number under the column marked "elevation" is the number of degrees the satellite is parked above your horizon. The next column of interest is the one marked "azimuth". This number is the heading, referenced to true north, to the satellite. You will have to add or subtract your local magnetic variation to use this number on a compass. I have included a magnetic variation chart that covers all the states. On some of the charts you will find a column marked "node". This is the longitude of the satellite. The other column is marked "distance" in miles from the satellite to your station location. On some of the charts there is one more column marked Polarization. This number indicates how far to the right or left you have to turn the feedhorn/LNA to receive one set of transponders or the other.

There are 24 transponders or transmitters on most satellites, 12 on what is called vertical and 12 on horizontal. That is in reference to the satellite. The lower the satellite is on your horizon the more the feedhorn has to rotate from your vertical to be aligned with the satellite's vertical. This is not hard to get right. Once you are receiving pictures you just rotate the feedhorn to get one polarization to disappear and that maximizes the other polarization. The numbers I have listed are close but not right on. Even if you are off by 45 degrees, the first time you fire up the system you will still see some video.

To use that last column you stand behind your feedhorn as it looks at your antenna. Visualize the face of a clock, with 12:00 being 0. To the right will be positive numbers and to the left are negative numbers. If you don't want to deal with this then just put the feedhorn so the widest opening is horizontal. You can tune it after the system is up and running. First you have to build the antenna!

What you would like to do is wander out to the place where your wife or husband has allowed you to put this creation and see if you can "see" the satellite. I told this to one chap and he called back to mourn the fact he could not have a satellite system. He related as how he had looked real hard and had even gotten out his binoculars and he still could not "see" the satellite.

You will need two things to test your station location for the different satellite look angles. The first item will be a compass, and the second is an inclinometer. Say what? The last item is a device that indicates the angle in degrees from level as it is tilted. It is used most often by carpenters and construction types. You can pick one up from Sears for about $20.00. If that is too steep for this project then I have just the thing for you.

If you look in the back of this section you will find an inclinometer drawn on a piece of paper. All you have to do is cut it out and paste it on a piece of wood, plastic, cardboard or whatever is handy. The short sides of the inclinometer will be placed against whatever you are measuring so make sure they are straight. Find a piece of wire about a number 14 or 16. Bend a curlycue in one end and pin it to the inclinometer so it hangs down the zero line when the long side of the inclinometer is held horizontal. To use this instrument or the one from Sears is simple. While standing where the antenna is alledged to be installed, tilt the inclinometer back by the number of degrees shown in the elevation column of the look angle chart. You can then site along the top of the inclinometer and see if the viewing angle to the satellite clears that tree or house. Before you can do that you have to know where to point the inclinometer. Find the chart that works best for your position and look up the true

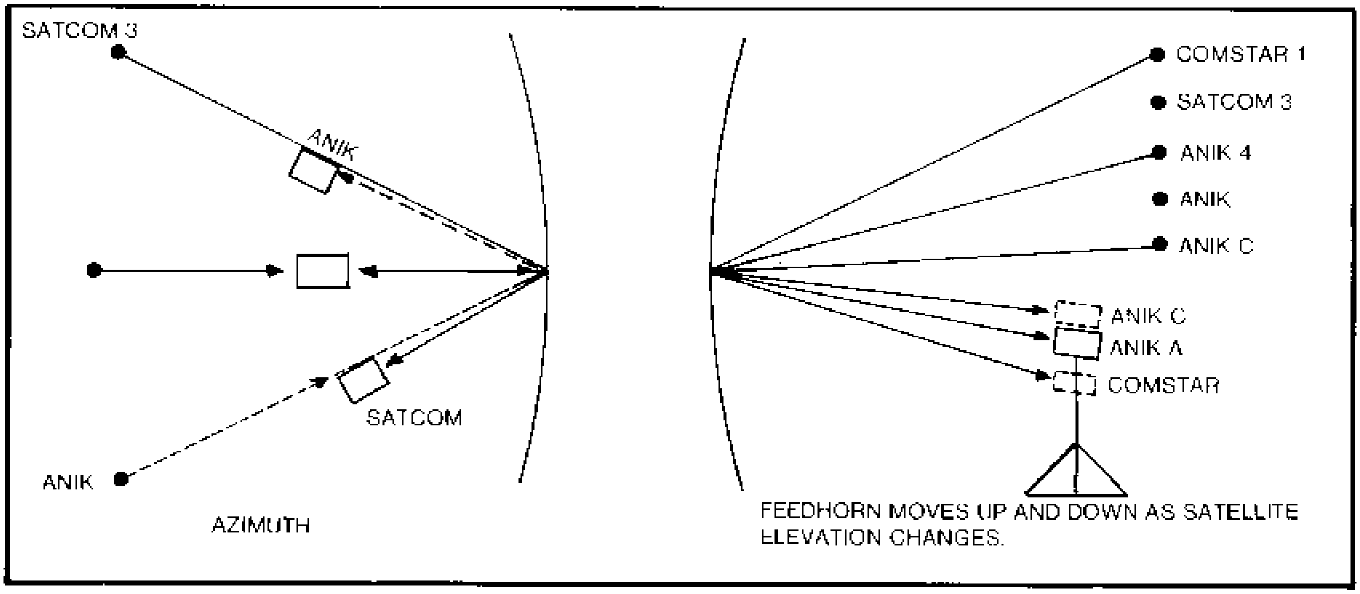


FIGURE 3.2

heading to the satellite. Then look up the variation for your area on the magnetic variation chart. You will notice it lists numbers like 2E, this means you want to turn your compass so the needle points to the east by 2 degrees. You can then look in the direction listed on the look angle chart for the satellite you are interested in. What this procedure does is to convert your compass to a true north reading compass.

Hopefully, after doing all the above, you have determined that you can indeed "see" the satellite of interest. That brings up a good point, which satellite do you want to look at? Well, the satellite most often watched is Satcom 3, as it is the one with most of the cable TV programming on it. If you can't see that one then try for Westar 4, Westar 5 or Satcom 4. They are all coming on strong with good programming. At the end of this section I have listed, to the best of my knowledge, some of the programs on the different satellites.

The 12 foot spherical antenna described in this manual is more than adequate for use on any of the satellites listed and from anywhere in the continental U.S. If you want to compute what kind of signal you will receive you can turn to the math section and, with the foot print charts listed, figure out what kind of quality to expect. If you have some particular use that a 12 footer is not up to, now is the time to find that out. You will also find a section on dimensions for antennas up to 20 feet.

The spherical antenna is capable of receiving multiple satellites at the same time. Figures 3.1 and 3.2 show how this is done. You can view a satellite as much as 15 degrees to either side of the point where the antenna is pointed. This means that you can view 30 degrees of the satellite arc without moving the antenna. As you go past the 15 degree mark the signal strength degrades too much to really use. The amount of satellite arc your antenna can see will depend on where you are in relation to the arc. I can only see 4 to 5 satellites before the signal degrades. People in Hawaii can see a lot more because the arc is compressed from their location. Look at the charts for San Jose and Hawaii. If you subtract the heading for Satcom 3 and Westar 4 for San Jose you get 49 degrees. Now do this for Hawaii and you get 23 degrees. In my case I can't view Satcom 3 and Westar 4 without moving the antenna. If I were to move to Hawaii I could easily see a lot more of the arc without moving the antenna. Pack the bags ma, we're moving to Hawaii!

To change satellites all you have to do is move your feed point structure to one side or the other to pick up the next satellite. You will have to move the feedhorn up or down as well. The satellites are at different elevations as well as azimuths. The first time you try to do this it will take a long time to work out. After you have marked the ground as to where to plant the feed point structure it will only take a second to go from one satellite to the other. You will notice that the antenna elevation is offset from the satellite by about 15 degrees. This is to keep the feedhorn and LNA from being too high off the ground. You would like to keep the feedhorn about 6 to 7 feet above the ground. If the feedhorn gets too low to the ground it will have to look to see the antenna and when it rains it will fill with water. Not good! Figure 3.3 shows how this all works graphically.

When I first turned on this antenna I had the antenna at a 30 degree angle. The satellite I was trying to see was Satcom 3 at 46 degrees. This put the feedhorn at about 8 feet. This was too high for me to get to so I moved the antenna so it was now at a 27 degree angle. This put the feedhorn at about the 6 to 7 foot point. The more the antenna is pointed directly at the satellite the stronger the signal will be, but we have to work on the system from time to time and I don't own a 20 foot ladder! So we compromise to get the system a little easier to work on but still perform up to our standards.

Satcom 3 Description of Video Services

1 **NICKELODEON**
A programming playground constructed to capture the spirit and curiosity of youngsters and adolescents.

1 **ARTS (Alpha Repertory Television Service)**
Presentation of performing, visual and lively arts designed to meet the special programming needs of viewers keenly interested in the fine arts.

2 **PTL (People That Love)**
Combining technical excellence and quality programs to provide 24-hour Christian entertainment. Viewing includes talk/variety, children's, drama, and specials from around the world.

3 **WGN**
Well-rounded programming format featuring movies, sports, specials, and syndicated progams. From Chicago's leading independent television station. (WGN-TV, Chicago, Channel 9.)

4 **SPOTLIGHT**
Pay television service featuring major motion pictures, specials, and some foreign and classic films. 24 hour service.

5 **THE MOVIE CHANNEL**
Reels and reels of movie programming. The entertainment runs non-stop from early a.m. to early a.m.

6 **WTBS**
Cable-oriented independent station. Family directed programs — sports, movies, quality syndication, national/international news, unique "Superstation" programming.

7 **ESPN (Entertainment & Sports Programming Network)**
The sports fanatics Shangri-La, featuring 1400 NCAA events.

8 **CBN (Christian Broadcasting Network)**
Christian music, news, sports, children's and family entertainment presented 24 hours per day, including Ross Bagley, the world's first video deejay, plus free phone-in prayer and counseling for viewers. Programs represent 67 different sources.

9 **USA NETWORK**
Features a package of 400 sporting events annually, includin NHL, Major League Baseball, NASL, NBA and MISL; Calliope, a children's series; the English Channel, YOU!, Night Flight; and cultural, women's and youth oriented programming.

9 **BET (Black Entertainment Network)**
Presenting quality programming featuring black performers in dominant or leading roles, feature films, classics, music specials and sports.

10 **SHOWTIME (West)**
Range of entertainment specials expands as Showtime ushers in Broadway and Off-Broadway plays. Also original made-for-pay programming, first run films, nightclub acts, and musical specials.

11 **MTV (Music Television)**
Twenty-four hour a day all stereo music channel featuring the best selling recording artists who sing and/or act out their songs. Current hits from the hottest new acts and "golden oldies".

12 **SHOWTIME (East)**
Same as Showtime transponder 10.

13 **HBO (West)**
The industry's most popular full service complement of first-run movies, sports and entertainment specials.

14 **CNN (Cable News Network)**
Twenty-four hour live news format. Round-the-clock news coverage developed specifically for the cable viewer. Headlines, in-depth reporting, hard news, sports, weather, features and financial reports; news when the viewer wants it.

15 **CNN 2 (Cable News Network)**
Continuously updated 30-minute wheel of hard news catered to the person who wants a quick fix of the news.

16 **HTN (Home Theatre Network)**
Good, clean family entertainment featuring a solid PG/G movie package.

16 **EPISCOPAL TV NETWORK**
Religious programming. Sunday 6 p.m. - 8 p.m.

16 **ACSN (Appalachian Community Service NETWORK**
Meeting the educational and cultural needs of communities throughout the country. Offering college-level and continuing education credit while viewing programs at home and providing timely topics of interest through public service programming. Mon.-Fri. 6 a.m.-4 p.m., Sat. & Sun., 6 a.m.-1 p.m.

16 **CMN (Christian Media Network)**
Programming of quality Christian movies, family entertainment, and visits to the great churches of America. Mon. 7 p.m.-2 a.m., Sat. & Sun. 9 p.m.-2 a.m.

16 **NJT (National Jewish Television)**
Programming of interest to Jewish viewers ranging from current affairs to entertainment to religious topics. On 1:00-4:00 p.m. (ET) Sundays.

16 **AETN (American Educational TV Network)**
Seven day a week programming. A continuing education television network for practicing professionals. Programming runs from 4:00-7:00 p.m. Tuesday through Saturday, 4:00-6:00 p.m. on Sunday, and 5:00-7:00 p.m. Monday (ET).

17 **CABLE HEALTH NETWORK**

18 **EWTH/REUTERS**

19 **C-SPAN**
Daily live coverage of the House of Representatives.

20 **CINEMAX (East)**
Designed specifically to complement HBO as a second service. All-movie service structured into time blocks according to female, children, family, or adult audience appeal.

21 **THE WEATHER CHANNEL**

22 **MSN (Modern Satellite Network)**
General Entertainment. Daytime, programming for women

22 **DON KING SPORTS**
Championship boxing and special events.
HBO Promochannel.

23 **CINEMAX (West)**
Same as Cinemax transponder 20.

24 **HBO (East)**
Same as HBO transponder 13.

HONOLULU, HAWAII

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GEOSTATIONARY SATELLITE ANTENNA BEARINGS

EARTH STATION AT :  157   :   50   :   0  W      21  :  30  :  0   N

SATELLITE          NODE          AZIMUTH           ELEVATION          DISTANCE(MI)

ATS-3               69           BELOW YOUR HORIZON BY   7.61477    DEGREES
GOES-1              75           BELOW YOUR HORIZON BY   2.03461    DEGREES
SATCOM 4            83           95.6736           5.44236             25528.9
COMSTAR 3           87           97.2598           9.21364             25275.6
WESTAR 3            91           98.9131           13.0101             25026
COMSTAR 2           95           100.652           16.8274             24781.3
WESTAR 4            99           102.499           20.6615             24542.9
ANIK A1             104          104.998           25.467              24255.8
SMS-1               105          105.528           26.4289             24200.1
ANIK A2             106.5        106.345           27.8715             24117.6
ANIK B              109          107.769           30.2726             23983.4
ANIK A3             114          110.894           35.0558             23728.2
-CTS-               116          112.266           36.9563             23631.5
SATCOM 2            119          114.479           39.7854             23492.8
WESTAR 5            123.5        118.218           43.9627             23299.8
COMSTAR 1           128          122.582           48.017              23126.5
SATCOM 3R           131          125.923           50.6251             23022.7
SATCOM 1            135          131.038           53.9374             22899.5
SMS-2               135          131.038           53.9374             22899.5
ATS-6               140          138.724           57.7124             22771.4
ATS-1               149          157.022           62.8904             22617.6
STATSIONAR 10       170          210.467           61.2777             22662.8
INTELSAT 4 F4       181          229.42            53.6701             22909.1
MARISAT 2           183          232.045           52.0311             22969.2
INTELSAT 4 F5       186          235.609           49.477              23067.6
STATSIONAR 7        220          259.048           17.4655             24741.1
-CS-                225          261.228           12.6926             25046.6
-ETS-               230          263.276           7.9534              25359.7
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ANCHORAGE, ALASKA

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EARTH STATION AT :  150   :   0   :   0  W       62  :   0   :   0  N
SATELLITE           NODE        AZIMUTH         ELEVATION          DISTANCE(MI)
ATS-3               69          BELOW YOUR HORIZON BY  4.48056   DEGREES
GOES-1              75          BELOW YOUR HORIZON BY  1.72109   DEGREES
SATCOM 4            83          110.545           1.88913            25771.4
COMSTAR 3           87          114.222           3.63779            25651.6
WESTAR 3            91          117.947           5.34499            25535.5
COMSTAR 2           95          121.726           7.0005             25423.7
WESTAR 4            99          125.565           8.5969             25316.7
ANIK A1             104         130.453           10.4941            25190.8
SMS-1               105         131.440           10.8575            25166.7
ANIK A2             106.5       132.936           11.3965            25131.4
ANIK B              109         135.447           12.2652            25074.5
ANIK A3             114         140.55            13.8918            24968.9
-CTS-               116         142.623           14.4984            24929.8
SATCOM 2            119         145.764           15.356             24874.8
WESTAR 5            123.5       150.548           16.519             24800.8
COMSTAR 1           128         155.412           17.524             24737.4
SATCOM 3R           131         158.695           18.0998            24701.3
SATCOM 1            135         163.118           18.7448            24661.1
SMS-2               135         163.118           18.7448            24661.1
ATS-6               140         168.706           19.3461            24623.8
ATS-1               149         178.867           19.8201            24594
STATSIONAR 10       170         202.403           17.9161            24712.8
INTELSAT 4 F4       181         214.206           15.356             24874.8
MARISAT 2         . 183         216.335           14.791             24911
INTELSAT 4 F8       186         219.45            13.8918            24968.9
STATSIONAR 7        220         252.184           .554337            25863.2
-CS-                225         BELOW YOUR HORIZON BY  1.7211  DEGREES
-ETS-               230         BELOW YOUR HORIZON BY  4.02313  DEGREES
-BSE-               250         BELOW YOUR HORIZON BY  18.7  DEGREES
STATSIONAR T        261         BELOW YOUR HORIZON BY  29.7  DEGREES
EKRAN 2             261         BELOW YOUR HORIZON BY  29.7  DEGREES
EKRAN 1             261         BELOW YOUR HORIZON BY  29.7  DEGREES
STATSIONAR 6        275         BELOW YOUR HORIZON BY  43.7  DEGREES
PALAPA 1            277         BELOW YOUR HORIZON BY  45.7  DEGREES
STATSIONAR 1        280         BELOW YOUR HORIZON BY  48.7  DEGREES
PALAPA 2            283         BELOW YOUR HORIZON BY  51.7  DEGREES
MARISAT 3           287         BELOW YOUR HORIZON BY  55.7  DEGREES
INTELSAT 4A F3      297         BELOW YOUR HORIZON BY  65.7  DEGREES
INTELSAT 4 F1       298.6       BELOW YOUR HORIZON BY  67.3  DEGREES
INTELSAT 4F6        300         BELOW YOUR HORIZON BY  68.7  DEGREES
INTELSAT 4 F5       300         BELOW YOUR HORIZON BY  68.7  DEGREES
STATSIONAR 5        302         BELOW YOUR HORIZON BY  70.7  DEGREES
SYMPHONIE 1         311         BELOW YOUR HORIZON BY  79.7  DEGREES
STATSIONAR 9        315         BELOW YOUR HORIZON BY  83.7  DEGREES
INTELSAT 4 F7       1           BELOW YOUR HORIZON BY  32.4295   DEGREES
INTELSAT 4 F2       4           BELOW YOUR HORIZON BY  31.6055   DEGREES
SYMPHONIE 2         11.5        BELOW YOUR HORIZON BY  29.2863   DEGREES
STATSIONAR 4        14          BELOW YOUR HORIZON BY  28.4376   DEGREES
SIRIC               15          BELOW YOUR HORIZON BY  28.0884   DEGREES
MARISAT 1           15          BELOW YOUR HORIZON BY  28.0884   DEGREES
INTELSAT 4A         19.5        BELOW YOUR HORIZON BY  26.4522   DEGREES
INTELSAT 4A F1      24.5        BELOW YOUR HORIZON BY  24.5207   DEGREES
STATSIONAR 8        25          BELOW YOUR HORIZON BY  24.3215   DEGREES
INTELSAT 4A F2      29.5        BELOW YOUR HORIZON BY  22.485  DEGREES
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MEDFORD, OREGON

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EARTH STATION AT :  122    :    52.3    :    0   W      42   :   22.3   :   0   N

SATELLITE            NODE        AZIMUTH            ELEVATION         DISTANCE(MI)

ATS-3                 69         116.195            17.5435            24736.2
GOES-1                75         121.365            21.6385            24483.4
SATCOM 4              83         128.898            26.7946            24179
COMSTAR 3             87         132.984            29.1994            24042.9
WESTAR 3              91         137.306            31.4575            23918.6
COMSTAR 2             95         141.879            33.5444            23807
WESTAR 4              99         146.709            35.4317            23708.9
ANIK A1               104        153.106            37.4687            23605.9
SMS-1                 105        154.431            37.8287            23588.1
ANIK A2               106.5      156.447            38.3378            23563
ANIK B                109        159.876            39.0971            23526
ANIK A3               114        166.96             40.265             23469.9
-CTS-                 116        169.862            40.5942            23454.3
SATCOM 2              119        174.266            40.9339            23438.3
WESTAR 5              123.5      180.932            41.0892            23431
COMSTAR 1             128        187.585            40.815             23443.9
SATCOM 3R             131        191.966            40.397             23463.7
SATCOM 1              135        197.686            39.5589            23503.7
SMS 2                 135        197.686            39.5589            23503.7
ATS-6                 140        204.574            38.0059            23575.4
ATS-1                 149        216.048            34.3928            23762.6
STATSIONAR 10         170        237.968            22.1339            24453.5
INTELSAT 4 F4         181        247.265            14.5553            24926.1
MARISAT 2             183        248.839            13.1328            25018
INTELSAT 4 F8         186        251.146            10.9818            25158.6
STATSIONAR 7          220        BELOW YOUR HORIZON BY   15.8283   DEGREES
-CS-                  225        BELOW YOUR HORIZON BY   20.8283   DEGREES
-ETS-                 230        BELOW YOUR HORIZON BY   25.8283   DEGREES
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SAN JOSE, CALIFORNIA

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EARTH STATION AT :  121    :    55.6    :    0  W     37  :   21.7  :   0   N

  TELLITE          NODE        AZIMUTH             ELEVATION         DISTANCE(MI)

ATS-3               69         114.632             20.4977             24552.9
GOES-1              75         119.568             25.0089             24282.6
SATCOM 4            83         126.92              30.736              23957.9
COMSTAR 3           87         130.992             33.4265             23813.3
WESTAR 3            91         135.367             35.965              23681.6
COMSTAR 2           95         140.071             38.3213             23563.8
WESTAR 4            99         145.124             40.4589             23460.7
ANIK A1             104        151.938             42.7681             23353.5
SMS-1               105        153.366             43.1755             23335.1
ANIK A2             106.5      155.548             43.7498             23309.3
ANIK B              109        159.282             44.6038             23271.5
ANIK A3             114        167.078             45.8942             23215.5
-CTS-               116        170.293             46.2440             23200.6
SATCOM 2            119        175.184             46.5831             23186.2
WESTAR 5            123.5      182.592             46.6611             23182.9
COMSTAR 1           128        189.945             46.2224             23201.5
SATCOM 3R           131        194.744             45.6497             23226
SATCOM 1            135        200.94              44.5569             23273.5
SMS-2               135        200.94              44.5569             23273.5
ATS-6               140        208.27              42.7074             23356.3
ATS-1               149        220.107             38.2385             23567.9
STATSIONAR 10       170        241.41              24.1504             24332.6
INTELSAT 4 F4       181        250.02              15.7520             24849.5
MARISAT 2           183        251.46              14.1903             24949.6
INTELSAT 4 F8       186        253.563             11.8353             25102.6
STATSIONAR 7        220        BELOW YOUR HORIZON BY  16.7733  DEGREES
-CS-                225        BELOW YOUR HORIZON BY  21.7733  DEGREES
-ETS-               230        BELOW YOUR HORIZON BY  26.7733  DEGREES
-BSE-               250        BELOW YOUR HORIZON BY  46.7733  DEGREES
STATSIONAR T        261        BELOW YOUR HORIZON BY  57.7733  DEGREES
EKRAN 2             261        BELOW YOUR HORIZON BY  57.7733  DEGREES
EKRAN 1             261        BELOW YOUR HORIZON BY  57.7733  DEGREES
STATSIONAR 6        275        BELOW YOUR HORIZON BY  71.7733  DEGREES
PALAPA 1            277        BELOW YOUR HORIZON BY  73.7733  DEGREES
STATSIONAR 1        280
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SEATTLE, WASHINGTON

EARTH STATION AT : 122 : 18.5 : 0 W 47 : 27 : 0 N

SATELLITE	NODE	AZIMUTH	ELEVATION	DISTANCE(MI)
ATS-3	69	118.764	15.4633	24868
GOES-1	75	124.2	19.0867	24639.8
SATCOM 4	83	131.981	23.5949	24366
COMSTAR 3	87	136.127	25.6708	24244
WESTAR 3	91	140.457	27.6025	24132.9
COMSTAR 2	95	144.975	29.3697	24033.4
WESTAR 4	99	149.679	30.9512	23946.2
ANIK A1	104	155.813	32.6349	23855.3
SMS-1	105	157.071	32.9295	23839.6
ANIK A2	106.5	158.977	33.3439	23817.6
ANIK B	109	162.199	33.9575	23785.3
ANIK A3	114	168.788	34.8845	23737
-CTS-	116	171.466	35.1383	23723.9
SATCOM 2	119	175.513	35.3708	23711
WESTAR 5	123.5	181.617	35.4741	23706.7
COMSTAR 1	128	187.705	35.2029	23720.6
SATCOM 3R	131	191.723	34.8285	23740
SATCOM 1	135	196.999	34.0935	23778.2
SMS-2	135	196.999	34.0935	23776.2
ATS-6	140	203.412	32.0187	23845.5
ATS-1	149	214.312	29.6269	24019.1
STATSIONAR 10	170	236.157	18.8606	24653.9
INTELSAT 4 F4	181	245.865	12.0807	25086.6
MARISAT 2	183	247.532	10.8	25170.6
INTELSAT 4 F8	186	249.987	8.85861	25299.3

SALT LAKE CITY, UTAH

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EARTH STATION AT :  111    :   59.5   :    0  W     40   :   37.3   :   0   N
SATELLITE             NODE          AZIMUTH             ELEVATION         DISTANCE(MI)
ATS-3                  69           124.93              25.9173            24229.7
GOES-1                 75           130.835             29.7079            24010.2
SATCOM 4               83           139.599             34.445             23759.9
COMSTAR 3              87           144.399             36.4957            23654.7
WESTAR 3               91           149.487             38.3213            23563.8
COMSTAR 2              95           154.857             39.8893            23487.8
WESTAR 4               99           160.487             41.1699            23427.3
ANIK A1                104          167.831             42.323             23373.9
SMS-1                  105          169.332             42.491             23366.2
ANIK A2                106.5        171.6               42.7005            23356.6
ANIK B                 109          175.411             42.9403            23345.7
ANIK A3                114          183.083             42.9958            23343.2
-CTS-                  116          186.143             42.8598            23349.4
SATCOM 2               119          190.693             42.4881            23366.3
WESTAR 5               123.5        197.366             41.566             23408.8
COMSTAR 1              128          203.782             40.2316            23471.5
SATCOM 3R              131          207.884             39.1328            23524.2
SATCOM 1               135          213.114             37.4311            23607.8
SMS-2                  135          213.114             37.4311            23607.8
ATS-6                  140          219.248             34.9682            23732.7
ATS-1                  149          229.182             29.7775            24010.7
STATSIONAR 10          170          247.869             15.3374            24876
INTELSAT 4 F4          181          255.974             7.1602             25413
MARISAT 2              183          257.37              5.65729            25514.3
INTELSAT 4 F8          186          259.431             3.39983            25667.9
STATSIONAR 7           220          BELOW  YOUR  HORIZON  BY   26.7083   DEGREES
-CS-                   225          BELOW  YOUR  HORIZON  BY   31.7083   DEGREES
-ETS-                  230          BELOW  YOUR  HORIZON  BY   36.7083   DEGREES
-BSE-                  250          BELOW  YOUR  HORIZON  BY   56.7083   DEGREES
STATSIONAR T           261          BELOW  YOUR  HORIZON  BY   67.7083   DEGREES
EKRAN 2                261          BELOW  YOUR  HORIZON  BY   67.7083   DEGREES
EKRAN 1                261          BELOW  YOUR  HORIZON  BY   67.7083   DEGREES
STATSIONAR 6           275          BELOW  YOUR  HORIZON  BY   81.7083   DEGREES
PALAPA 1               277          BELOW  YOUR  HORIZON  BY   83.7083   DEGREES
STATSIONAR 1           280          BELOW  YOUR  HORIZON  BY   86.7083   DEGREES
PALAPA 2               283          BELOW  YOUR  HORIZON  BY   89.7083   DEGREES
MARISAT 3              287          BELOW  YOUR  HORIZON  BY   93.7083   DEGREES
INTELSAT 4A F3         297          BELOW  YOUR  HORIZON  BY   57.8242   DEGREES
INTELSAT 4 F1          298.6        BELOW  YOUR  HORIZON  BY   57.6367   DEGREES
INTELSAT 4F6           300          BELOW  YOUR  HORIZON  BY   57.4314   DEGREES
INTELSAT 4 F5          300          BELOW  YOUR  HORIZON  BY   57.4314   DEGREES
STATSIONAR 5           302          BELOW  YOUR  HORIZON  BY   57.0723   DEGREES
SYMPHONIE 1            311          BELOW  YOUR  HORIZON  BY   54.5599   DEGREES
STATSIONAR 9           315          BELOW  YOUR  HORIZON  BY   53.0185   DEGREES
INTELSAT 4 F7          1            BELOW  YOUR  HORIZON  BY   24.478   DEGREES
INTELSAT 4 F2          4            BELOW  YOUR  HORIZON  BY   22.2593   DEGREES
SYMPHONIE 2            11.5         BELOW  YOUR  HORIZON  BY   16.6447   DEGREES
STATSIONAR 4           14           BELOW  YOUR  HORIZON  BY   14.7578   DEGREES
SIRIC                  15           BELOW  YOUR  HORIZON  BY   14.0015   DEGREES
MARISAT 1              15           BELOW  YOUR  HORIZON  BY   14.0015   DEGREES
INTELSAT 4A            19.5         BELOW  YOUR  HORIZON  BY   10.5912   DEGREES
INTELSAT 4A F1         24.5         BELOW  YOUR  HORIZON  BY   6.79662   DEGREES
STATSIONAR 8           25           BELOW  YOUR  HORIZON  BY   6.4173   DEGREES
INTELSAT 4A F2         29.5         BELOW  YOUR  HORIZON  BY   3.00818   DEGREES
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PHOENIX, ARIZONA

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EARTH STATION AT :  112     :    .5    :     0   W        33   :   26.2   :   0   N
SATELLITE            NODE           AZIMUTH              ELEVATION            DISTANCE(MI)
ATS-3                 69            120.571              30.0991                23993
GOES-1                75            126.167              34.6528                23749.1
SATCOM 4              83            134.819              40.2519                23470.6
COMSTAR 3             87            139.749              42.7706                23353.4
WESTAR 3              91            145.125              45.0472                23252.1
COMSTAR 2             95            150.964              47.0309                23167.4
WESTAR 4              99            157.253              48.6751                23099.8
ANIK A1               104           165.677              50.1765                23040.1
SMS-1                 105           167.423              50.3963                23031.5
ANIK A2               106.5         170.073              50.6728                23020.8
ANIK B                109           174.552              50.9073                23008.6
ANIK A3               114           183.611              51.0659                23005.7
-CTS-                 116           187.218              50.8864                23012.6
SATCOM 2              119           192.548              50.3997                23031.4
WESTAR 5              123.5         200.252              49.1991                23078.7
COMSTAR 1             128           207.479              47.4837                23148.5
SATCOM 3R             131           211.909              46.0864                23207.3
SATCOM 1              135           217.598              43.9513                23300.3
SMS-2                 135           217.598              43.9513                23300.3
ATS-6                 140           223.968              40.9125                23439.3
ATS-1                 149           233.817              34.6647                23748.4
STATSIONAR 10         170           250.995              17.9943                24707.9
INTELSAT 4 F4         181           258.052              8.82568                25301.5
MARISAT 2             183           259.252              7.15371                25413.4
INTELSAT 4 F8         186           261.017              4.64804                25582.8
STATSIONAR 7          220           BELOW  YOUR  HORIZON  BY   26.6917   DEGREES
 -CS-                 225           BELOW  YOUR  HORIZON  BY   31.6917   DEGREES
 -ETS-                230           BELOW  YOUR  HORIZON  BY   36.6917   DEGREES
 -BSE-                250           BELOW  YOUR  HORIZON  BY   56.6917   DEGREES
STATSIONAR T          261           BELOW  YOUR  HORIZON  BY   67.6917   DEGREES
EKRAN 2               261           BELOW  YOUR  HORIZON  BY   67.6917   DEGREES
EKRAN 1               261           BELOW  YOUR  HORIZON  BY   67.6917   DEGREES
STATSIONAR 6          275           BELOW  YOUR  HORIZON  BY   81.6917   DEGREES
PALAPA 1              277           BELOW  YOUR  HORIZON  BY   83.6917   DEGREES
STATSIONAR 1          280           BELOW  YOUR  HORIZON  BY   86.6917   DEGREES
PALAPA 2              283           BELOW  YOUR  HORIZON  BY   89.6917   DEGREES
MARISAT 3             287           BELOW  YOUR  HORIZON  BY   93.6917   DEGREES
INTELSAT 4A F3        297           BELOW  YOUR  HORIZON  BY   64.9559   DEGREES
INTELSAT 4 F1         298.6         BELOW  YOUR  HORIZON  BY   64.6942   DEGREES
INTELSAT 4F6          300           BELOW  YOUR  HORIZON  BY   64.43  DEGREES
INTELSAT 4 F5         300           BELOW  YOUR  HORIZON  BY   64.43  DEGREES
STATSIONAR 5          302           BELOW  YOUR  HORIZON  BY   63.9695   DEGREES
SYMPHONIE 1           311           BELOW  YOUR  HORIZON  BY   60.799   DEGREES
STATSIONAR 9          315           BELOW  YOUR  HORIZON  BY   58.8932   DEGREES
INTELSAT 4 F7         1             BELOW  YOUR  HORIZON  BY   26.108   DEGREES
INTELSAT 4 F2         4             BELOW  YOUR  HORIZON  BY   23.651   DEGREES
SYMPHONIE 2           11.5          BELOW  YOUR  HORIZON  BY   17.4543   DEGREES
STATSIONAR 4          14            BELOW  YOUR  HORIZON  BY   15.3765   DEGREES
SIRIC                 15            BELOW  YOUR  HORIZON  BY   14.5442   DEGREES
MARISAT 1             15            BELOW  YOUR  HORIZON  BY   14.5442   DEGREES
INTELSAT 4A           19.5          BELOW  YOUR  HORIZON  BY   10.7933   DEGREES
INTELSAT 4A F1        24.5          BELOW  YOUR  HORIZON  BY   6.62117   DEGREES
STATSIONAR 8          25            BELOW  YOUR  HORIZON  BY   6.20407   DEGREES
INTELSAT 4A F2        29.5          BELOW  YOUR  HORIZON  BY   2.45393   DEGREES
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DALLAS, TEXAS

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EARTH STATION AT :  96   :   51.1   :    0  W     32  :   50.8  :   0  N
  TELLITE           NODE       AZIMUTH           ELEVATION          DISTANCE(MI)
ATS-3                69        135.749            41.4738             23413.1
GOES-1               75        143.525            45.1221             23248.8
SATCOM 4             83        155.553            48.9665             23098
COMSTAR 3            87        162.246            50.3353             23033.9
WESTAR 3             91        169.3              51.2722             22997.8
COMSTAR 2            95        176.589            51.741              22980.1
WESTAR 4             99        183.956            51.723              22980.7
ANIK A1              104       193.019            51.0189             23007.5
SMS-1                105       194.738            50.7894             23016.3
ANIK A2              106.5     197.403            50.374              23031.6
ANIK B               109       201.647            49.5991             23062.8
ANIK A3              114       209.605            47.5451             23146
-CTS-                116       212.626            46.5679             23186.9
SATCOM 2             119       216.887            44.9551             23256.1
WESTAR 5             123.5     222.775            42.2491             23377.3
COMSTAR 1            128       228.075            39.2571             23518.2
SATCOM 3R            131       231.352            37.1349             23622.6
SATCOM 1             135       235.373            34.1751             23773.9
SMS-2                135       235.373            34.1751             23773.9
ATS-6                140       239.745            30.3117             23981.2
ATS 1                149       247.144            23.0439             24398.8
STATSIONAR 10        170       260.67             5.44956             25528.4
INTELSAT 4 F4        181       BELOW YOUR HORIZON BY   2.84833   DEGREES
MARISAT 2            183       BELOW YOUR HORIZON BY   4.84833   DEGREES
INTELSAT 4 F8        186       BELOW YOUR HORIZON BY   7.84833   DEGREES
STATSIONAR 7         220       BELOW YOUR HORIZON BY   41.8483   DEGREES
-CS-                 225       BELOW YOUR HORIZON BY   46.8483   DEGREES
-ETS-                230       BELOW YOUR HORIZON BY   51.8483   DEGREES
-BSE-                250       BELOW YOUR HORIZON BY   71.8483   DEGREES
STATSIONAR T         261       BELOW YOUR HORIZON BY   82.8483   DEGREES
EKRAN 2              261       BELOW YOUR HORIZON BY   82.8483   DEGREES
EKRAN 1              261       BELOW YOUR HORIZON BY   82.8483   DEGREES
STATSIONAR 6         275       BELOW YOUR HORIZON BY   96.8483   DEGREES
PALAPA 1             277       BELOW YOUR HORIZON BY   65.0532   DEGREES
STATSIONAR 1         280       BELOW YOUR HORIZON BY   65.7198   DEGREES
PALAPA 2             283       BELOW YOUR HORIZON BY   65.3465   DEGREES
MARISAT 3            287       BELOW YOUR HORIZON BY   64.4901   DEGREES
INTELSAT 4A F3       297       BELOW YOUR HORIZON BY   60.7656   DEGREES
INTELSAT 4 F1        298.6     BELOW YOUR HORIZON BY   59.9906   DEGREES
INTELSAT 4F6         300       BELOW YOUR HORIZON BY   59.278  DEGREES
INTELSAT 4 F5        300       BELOW YOUR HORIZON BY   59.278  DEGREES
STATSIONAR 5         302       BELOW YOUR HORIZON BY   58.2077   DEGREES
SYMPHONIE 1          311       BELOW YOUR HORIZON BY   52.7495   DEGREES
STATSIONAR 9         315       BELOW YOUR HORIZON BY   50.0525   DEGREES
INTELSAT 4 F7        1         BELOW YOUR HORIZON BY   13.6139   DEGREES
INTELSAT 4 F2        4         BELOW YOUR HORIZON BY   11.0957   DEGREES
SYMPHONIE 2          11.5      BELOW YOUR HORIZON BY   4.79634   DEGREES
STATSIONAR 4         14        BELOW YOUR HORIZON BY   2.69936   DEGREES
SIRIC                15        BELOW YOUR HORIZON BY   1.86147   DEGREES
   RISAT 1           15        BELOW YOUR HORIZON BY   1.86147   DEGREES
INTELSAT 4A          19.5      96.9399            1.91956             25769.3
INTELSAT 4A F1       24.5      99.7906            6.12045             25483
STATSIONAR 8         25        100.081            6.54086             25454.7
INTELSAT 4A F2       29.5      102.752            10.3315             25201.5
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WICHITA, KANSAS

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EARTH STATION AT :  97   :   26    :    0  W       37  :   40   :  0  N
  TELLITE          NODE        AZIMUTH            ELEVATION          DISTANCE(MI)
ATS-3               69         138.457            37.2066             23619
GOES-1              75         145.956            40.4258             23462.3
SATCOM 4            83         157.16             43.7906             23307.5
COMSTAR 3           87         163.231            44.9923             23254.5
WESTAR 3            91         169.545            45.8281             23218.3
COMSTAR 2           95         176.022            46.2755             23199.3
WESTAR 4            99         182.563            46.3188             23197.4
ANIK A1             104        190.669            45.8069             23219.3
SMS-1               105        192.264            45.6302             23226.8
ANIK A2             106.5      194.636            45.3207             23240.2
ANIK B              109        198.517            44.6873             23267.8
ANIK A3             114        205.958            43.012              23342.5
-CTS-               116        208.797            42.2001             23379.5
SATCOM 2            119        212.896            40.846              23442.5
WESTAR 5            123.5      218.678            38.5378             23553.2
COMSTAR 1           128        224.025            35.9446             23682.6
SATCOM 3R           131        227.358            34.0827             23778.8
SATCOM 1            135        231.535            31.4601             23918.5
SMS-2               135        231.535            31.4601             23918.5
ATS-6               140        236.364            27.9989             24110.4
ATS-1               149        244.131            21.3925             24498.3
STATSIONAR 10       170        259.138            5.06733             25554.4
INTELSAT 4 F4       181        BELOW YOUR HORIZON BY   2.26666   DEGREES
   RISAT 2          183        BELOW YOUR HORIZON BY   4.26666   DEGREES
INTELSAT 4 F8       186        BELOW YOUR HORIZON BY   7.26666   DEGREES
STATSIONAR 7        220        BELOW YOUR HORIZON BY   41.2667   DEGREES
-CS-                225        BELOW YOUR HORIZON BY   46.2667   DEGREES
-ETS-               230        BELOW YOUR HORIZON BY   51.2667   DEGREES
-BSE-               250        BELOW YOUR HORIZON BY   71.2667   DEGREES
STATSIONAR T        261        BELOW YOUR HORIZON BY   82.2667   DEGREES
EKRAN 2             261        BELOW YOUR HORIZON BY   82.2667   DEGREES
EKRAN 1             261        BELOW YOUR HORIZON BY   82.2667   DEGREES
STATSIONAR 6        275        BELOW YOUR HORIZON BY   96.2667   DEGREES
PALAPA 1            277        BELOW YOUR HORIZON BY   98.2667   DEGREES
STATSIONAR 1        280        BELOW YOUR HORIZON BY   60.9592   DEGREES
PALAPA 2            283        BELOW YOUR HORIZON BY   60.6849   DEGREES
MARISAT 3           287        BELOW YOUR HORIZON BY   60.0131   DEGREES
INTELSAT 4A F3      297        BELOW YOUR HORIZON BY   56.9339   DEGREES
INTELSAT 4 F1       298.6      BELOW YOUR HORIZON BY   56.2764   DEGREES
INTELSAT 4F6        300        BELOW YOUR HORIZON BY   55.6681   DEGREES
INTELSAT 4 F5       300        BELOW YOUR HORIZON BY   55.6681   DEGREES
STATSIONAR 5        302        BELOW YOUR HORIZON BY   54.7484   DEGREES
SYMPHONIE 1         311        BELOW YOUR HORIZON BY   49.9679   DEGREES
STATSIONAR 9        315        BELOW YOUR HORIZON BY   47.5618   DEGREES
INTELSAT 4 F7       1          BELOW YOUR HORIZON BY   13.7887   DEGREES
INTELSAT 4 F2       4          BELOW YOUR HORIZON BY   11.4174   DEGREES
SYMPHONIE 2         11.5       BELOW YOUR HORIZON BY   5.48218   DEGREES
STATSIONAR 4        14         BELOW YOUR HORIZON BY   3.50648   DEGREES
SIRIC               15         BELOW YOUR HORIZON BY   2.71716   DEGREES
  RISAT 1           15         BELOW YOUR HORIZON BY   2.71716   DEGREES
INTELSAT 4A         19.5       97.4424             .840126            25843.5
INTELSAT 4A F1      24.5       100.625             4.77796            25574
STATSIONAR 8        25         100.949             5.17186            25547.2
INTELSAT 4A F2      29.5       103.913             8.71597            25308.8
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NORTH DAKOTA

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EARTH STATION AT :  100     :    0    :    0  W       45  :   30   :   0   N
SATELLITE        NODE      AZIMUTH         ELEVATION        DISTANCE(MI)
ATS-3             69        139.888         29.3639           24033.7
GOES-1            75        146.824         32.0864           23884.7
SATCOM 4          83        156.798         34.9817           23732
COMSTAR 3         87        162.064         36.0622           23676.7
WESTAR 3          91        167.48          36.8719           23635.8
COMSTAR 2         95        173.007         37.3954           23609.6
WESTAR 4          99        178.598         37.6223           23598.3
ANIK A1           104       185.599         37.48             23605.4
SMS-1             105       186.993         37.3954           23609.6
ANIK A2           106.5     189.076         37.2341           23617.6
ANIK B            109       192.52          36.8719           23635.8
ANIK A3           114       199.268         35.8165           23689.2
-CTS-             116       201.901         35.2763           23716.9
SATCOM 2          119       205.769         34.3458           23765
WESTAR 5          123.5     211.367         32.698            23851.9
COMSTAR 1         128       216.704         30.7786           23955.6
SATCOM 3R         131       220.112         29.3639           24033.7
SATCOM 1          135       224.471         27.3305           24148.4
SMS-2             135       224.471         27.3305           24148.4
ATS-6             140       229.635         24.5817           24307.7
ATS-1             149       238.2           19.1765           24634.3
STATSIONAR 10     170       255.447         5.2207            25543.9
INTELSAT 4 F4     181       BELOW YOUR HORIZON BY  2.40532  DEGREES
MARISAT 2         183       BELOW YOUR HORIZON BY  1.7  DEGREES
INTELSAT 4 F8     186       BELOW YOUR HORIZON BY  4.7  DEGREES
STATSIONAR 7      220       BELOW YOUR HORIZON BY  38.7  DEGREES
-CS-              225       BELOW YOUR HORIZON BY  43.7  DEGREES
-ETS-             230       BELOW YOUR HORIZON BY  48.7  DEGREES
-BSE-             250       BELOW YOUR HORIZON BY  68.7  DEGREES
STATSIONAR T      261       BELOW YOUR HORIZON BY  79.7  DEGREES
EKRAN 2           261       BELOW YOUR HORIZON BY  79.7  DEGREES
EKRAN 1           261       BELOW YOUR HORIZON BY  79.7  DEGREES
STATSIONAR 6      275       BELOW YOUR HORIZON BY  93.7  DEGREES
PALAPA 1          277       BELOW YOUR HORIZON BY  95.7  DEGREES
STATSIONAR 1      280       BELOW YOUR HORIZON BY  98.7  DEGREES
PALAPA 2          283       BELOW YOUR HORIZON BY  53.1231  DEGREES
MARISAT 3         287       BELOW YOUR HORIZON BY  52.782  DEGREES
INTELSAT 4A F3    297       BELOW YOUR HORIZON BY  50.7891  DEGREES
INTELSAT 4 F1     298.6     BELOW YOUR HORIZON BY  50.3288  DEGREES
INTELSAT 4F6      300       BELOW YOUR HORIZON BY  49.8964  DEGREES
INTELSAT 4 F5     300       BELOW YOUR HORIZON BY  49.8964  DEGREES
STATSIONAR 5      302       BELOW YOUR HORIZON BY  49.2322  DEGREES
SYMPHONIE 1       311       BELOW YOUR HORIZON BY  45.6272  DEGREES
STATSIONAR 9      315       BELOW YOUR HORIZON BY  43.7405  DEGREES
INTELSAT 4 F7     1         BELOW YOUR HORIZON BY  14.9952  DEGREES
INTELSAT 4 F2     4         BELOW YOUR HORIZON BY  12.9018  DEGREES
SYMPHONIE 2       11.5      BELOW YOUR HORIZON BY  7.64095  DEGREES
STATSIONAR 4      14        BELOW YOUR HORIZON BY  5.89777  DEGREES
   RIC            15        BELOW YOUR HORIZON BY  5.19797  DEGREES
MARISAT 1         15        BELOW YOUR HORIZON BY  5.19797  DEGREES
INTELSAT 4A       19.5      BELOW YOUR HORIZON BY  2.05721  DEGREES
INTELSAT 4A F1    24.5      100.451         1.42432           25803.3
STATSIONAR 8      25        100.82          1.77033           25779.5
INTELSAT 4A F2    29.5      104.175         4.87669           25567.3
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NEW ORLEANS, LOUISIANA

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EARTH STATION AT :  90    :   0   :    0  W       30  :  0  :  0  N
SATELLITE          NODE        AZIMUTH          ELEVATION          DISTANCE(MI)
ATS-3               69         142.486          48.17               23120.3
GOES-1              75         151.813          51.3633             22994.3
SATCOM 4            83         166.203          54.2002             22890.2
COMSTAR 3           87         174.016          54.8806             22866.3
WESTAR 3            91         181.999          55.018              22861.5
COMSTAR 2           95         189.925          54.607              22875.8
WESTAR 4            99         197.577          53.6664             22909.2
ANIK A1             104        206.503          51.8149             22977.3
SMS-1               105        208.187          51.3633             22994.3
ANIK A2             106.5      210.644          50.6404             23022.1
ANIK B              109        214.553          49.3199             23073.9
ANIK A3             114        221.684          46.3057             23198
-CTS-               116        224.288          44.9805             23255
SATCOM 2            119        227.949          42.8868             23348.1
WESTAR 5            123.5      232.932          39.5464             23504.3
COMSTAR 1           128        237.382          36.0187             23678.9
SATCOM 3R           131        240.093          33.5862             23804.8
SATCOM 1            135        243.435          30.2668             23983.7
SMS-2               135        243.435          30.2668             23983.7
ATS-6               140        247.24           26.0265             24223.3
ATS-1               149        253.278          18.2438             24692.3
STATSIONAR 10       170        BELOW YOUR HORIZON BY  .0510864  DEGREES
INTELSAT 4 F4       181        BELOW YOUR HORIZON BY  9.7  DEGREES
MARISAT 2           183        BELOW YOUR HORIZON BY  11.7  DEGREES
INTELSAT 4 F8       186        BELOW YOUR HORIZON BY  14.7  DEGREES
STATSIONAR 7        220        BELOW YOUR HORIZON BY  48.7  DEGREES
-CS-                225        BELOW YOUR HORIZON BY  53.7  DEGREES
-ETS-               230        BELOW YOUR HORIZON BY  58.7  DEGREES
-BSE-               250        BELOW YOUR HORIZON BY  78.7  DEGREES
STATSIONAR T        261        BELOW YOUR HORIZON BY  89.7  DEGREES
EKRAN 2             261        BELOW YOUR HORIZON BY  89.7  DEGREES
EKRAN 1             261        BELOW YOUR HORIZON BY  89.7  DEGREES
STATSIONAR 6        275        BELOW YOUR HORIZON BY  68.3247   DEGREES
PALAPA 1            277        BELOW YOUR HORIZON BY  67.9686   DEGREES
STATSIONAR 1        280        BELOW YOUR HORIZON BY  67.2253   DEGREES
PALAPA 2            283        BELOW YOUR HORIZON BY  66.247  DEGREES
MARISAT 3           287        BELOW YOUR HORIZON BY  64.6129   DEGREES
INTELSAT 4A F3      297        BELOW YOUR HORIZON BY  59.2011   DEGREES
INTELSAT 4 F1       298.6      BELOW YOUR HORIZON BY  58.1958   DEGREES
INTELSAT 4F6        300        BELOW YOUR HORIZON BY  57.2906   DEGREES
INTELSAT 4 F5       300        BELOW YOUR HORIZON BY  57.2906   DEGREES
STATSIONAR 5        302        BELOW YOUR HORIZON BY  55.9594   DEGREES
SYMPHONIE 1         311        BELOW YOUR HORIZON BY  49.5137   DEGREES
STATSIONAR 9        315        BELOW YOUR HORIZON BY  46.4615   DEGREES
INTELSAT 4 F7       1          BELOW YOUR HORIZON BY  7.83424   DEGREES
INTELSAT 4 F2       4          BELOW YOUR HORIZON BY  5.23686   DEGREES
SYMPHONIE 2         11.5       95.8085          1.25867             25814.7
STATSIONAR 4        14         97.106           3.42348             25666.3
   RIC              15         97.6307          4.29141             25607.1
MARISAT 1           15         97.6307          4.29141             25607.1
INTELSAT 4A         19.5       100.041          8.20707             25342.8
INTELSAT 4A F1      24.5       102.836          12.5708             25054.6
STATSIONAR 8        25         103.124          13.0075             25026.1
INTELSAT 4A F2      29.5       105.795          16.9362             24774.4
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MEMPHIS, TENNESSEE

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EARTH STATION AT :  89    :   58.7    :    0   W        35   :   3   :   0   N
SATELLITE          NODE         AZIMUTH            ELEVATION          DISTANCE(MI)
ATS-3               69          146.271            43.5713             23317.3
GOES-1              75          155.021            46.2719             23199.4
SATCOM 4            83          167.968            48.6201             23102
COMSTAR 3           87          174.823            49.1738             23079.7
WESTAR 3            91          181.779            49.2835             23075.3
COMSTAR 2           95          188.699            48.9457             23088.9
WESTAR 4            99          195.454            48.1717             23120.2
ANIK A1             104         203.502            46.6333             23184.1
SMS-1               105         205.046            46.2553             23200.1
ANIK A2             106.5       207.317            45.6466             23226.1
ANIK B              109         210.977            44.5297             23274.7
ANIK A3             114         217.813            41.9472             23391.2
-CTS-               116         220.368            40.799              23444.7
SATCOM 2            119         224.011            38.9709             23532.1
WESTAR 5            123.5       229.076            36.0227             23678.7
COMSTAR 1           128         233.703            32.8726             23842.6
SATCOM 3R           131         236.57             30.6814             23960.9
SATCOM 1            135         240.15             27.6701             24129
SMS-2               135         240.15             27.6701             24129
ATS-6               140         244.288            23.7917             24354.3
ATS-1               149         250.977            16.6001             24795.7
STATSIONAR 10       170         BELOW YOUR HORIZON BY   .545212   DEGREES
INTELSAT 4 F4       181         BELOW YOUR HORIZON BY  9.72166    DEGREES
MARISAT 2           183         BELOW YOUR HORIZON BY  11.7217    DEGREES
INTELSAT 4 F8       186         BELOW YOUR HORIZON BY  14.7217    DEGREES
STATSIONAR 7        220         BELOW YOUR HORIZON BY  48.7217    DEGREES
-CS-                225         BELOW YOUR HORIZON BY  53.7217    DEGREES
-ETS-               230         BELOW YOUR HORIZON BY  58.7217    DEGREES
-BSE-               250         BELOW YOUR HORIZON BY  78.7217    DEGREES
STATSIONAR T        261         BELOW YOUR HORIZON BY  89.7217    DEGREES
EKRAN 2             261         BELOW YOUR HORIZON BY  89.7217    DEGREES
EKRAN 1             261         BELOW YOUR HORIZON BY  89.7217    DEGREES
STATSIONAR 6        275         BELOW YOUR HORIZON BY  63.3379    DEGREES
PALAPA 1            277         BELOW YOUR HORIZON BY  63.0422    DEGREES
STATSIONAR 1        280         BELOW YOUR HORIZON BY  62.4227    DEGREES
PALAPA 2            283         BELOW YOUR HORIZON BY  61.6017    DEGREES
MARISAT 3           287         BELOW YOUR HORIZON BY  60.2169    DEGREES
INTELSAT 4A F3      297         BELOW YOUR HORIZON BY  55.5266    DEGREES
INTELSAT 4 F1       298.6       BELOW YOUR HORIZON BY  54.6404    DEGREES
INTELSAT 4F6        300         BELOW YOUR HORIZON BY  53.8391    DEGREES
INTELSAT 4 F5       300         BELOW YOUR HORIZON BY  53.8391    DEGREES
STATSIONAR 5        302         BELOW YOUR HORIZON BY  52.6551    DEGREES
SYMPHONIE 1         311         BELOW YOUR HORIZON BY  46.8443    DEGREES
STATSIONAR 9        315         BELOW YOUR HORIZON BY  44.0562    DEGREES
INTELSAT 4 F7       1           BELOW YOUR HORIZON BY  7.86388    DEGREES
INTELSAT 4 F2       4           BELOW YOUR HORIZON BY  5.40881    DEGREES
SYMPHONIE 2         11.5        96.677              .726021            25851.4
STATSIONAR 4        14          98.1615            2.76472             25711.3
  RIC               15          98.7611            3.58116             25655.5
MARISAT 1           15          98.7611            3.58116             25655.5
INTELSAT 4A         19.5        101.509            7.26116             25406.2
INTELSAT 4A F1      24.5        104.681            11.348              25134.6
STATSIONAR 8        25          105.006            11.7563             25107.8
INTELSAT 4A F2      29.5        108.015            15.4198             24870.7
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CHICAGO, ILLINOIS

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EARTH STATION AT :  87    :   45.1     :    0  W     41   :   47.2  :  0   N
SATELLITE          NODE      AZIMUTH             ELEVATION          DISTANCE(MI)
ATS-3               69       153.003             38.0886             23575.2
GOES-1              75       161.242             40.014              23481.9
SATCOM 4            83       172.89              41.4997             23411.9
COMSTAR 3           87       178.872             41.7378             23400.8
WESTAR 3            91       184.868             41.629              23405.9
COMSTAR 2           95       190.806             41.1766             23426.9
WESTAR 4            99       196.618             40.3914             23463.9
ANIK A1             104      203.623             38.97               23532.1
SMS-1               105      204.982             38.6311             23548.6
ANIK A2             106.5    206.993             38.09               23575.2
ANIK B              109      210.265             37.1057             23624.1
ANIK A3             114      216.502             34.8513             23738.8
-CTS-               116      218.879             33.8542             23790.7
SATCOM 2            119      222.32              32.2666             23875
WESTAR 5            123.5    227.21              29.7019             24014.9
COMSTAR 1           128      231.791             26.9518             24170
SATCOM 3R           131      234.686             25.0311             24281.3
SATCOM 1            135      238.366             22.3805             24438.6
SMS-2               135      238.366             22.3805             24438.6
ATS-6               140      242.707             18.9503             24648.3
ATS-1               149      249.918             12.5407             25056.5
STATSIONAR 10       170      BELOW YOUR HORIZON BY   .948334     DEGREES
INTELSAT 4 F4       181      BELOW YOUR HORIZON BY   11.9483     DEGREES
MARISAT 2           183      BELOW YOUR HORIZON BY   13.9483     DEGREES
INTELSAT 4 F8       186      BELOW YOUR HORIZON BY   16.9483     DEGREES
STATSIONAR 7        220      BELOW YOUR HORIZON BY   50.9483     DEGREES
-CS-                225      BELOW YOUR HORIZON BY   55.9483     DEGREES
-ETS-               230      BELOW YOUR HORIZON BY   60.9483     DEGREES
-BSE-               250      BELOW YOUR HORIZON BY   80.9483     DEGREES
STATSIONAR T        261      BELOW YOUR HORIZON BY   91.9483     DEGREES
EKRAN 2             261      BELOW YOUR HORIZON BY   91.9483     DEGREES
EKRAN 1             261      BELOW YOUR HORIZON BY   91.9483     DEGREES
STATSIONAR 6        275      BELOW YOUR HORIZON BY   56.4037     DEGREES
PALAPA 1            277      BELOW YOUR HORIZON BY   56.0868     DEGREES
STATSIONAR 1        280      BELOW YOUR HORIZON BY   55.4743     DEGREES
PALAPA 2            283      BELOW YOUR HORIZON BY   54.7036     DEGREES
MARISAT 3           287      BELOW YOUR HORIZON BY   53.4449     DEGREES
INTELSAT 4A F3      297      BELOW YOUR HORIZON BY   49.2849     DEGREES
INTELSAT 4 F1       298.6    BELOW YOUR HORIZON BY   48.5029     DEGREES
INTELSAT 4F6        300      BELOW YOUR HORIZON BY   47.7956     DEGREES
INTELSAT 4 F5       300      BELOW YOUR HORIZON BY   47.7956     DEGREES
STATSIONAR 5        302      BELOW YOUR HORIZON BY   46.7498     DEGREES
SYMPHONIE 1         311      BELOW YOUR HORIZON BY   41.5959     DEGREES
STATSIONAR 9        315      BELOW YOUR HORIZON BY   39.108    DEGREES
INTELSAT 4 F7       1        BELOW YOUR HORIZON BY   6.27876     DEGREES
INTELSAT 4 F2       4        BELOW YOUR HORIZON BY   4.0454    DEGREES
SYMPHONIE 2         11.5     99.2598             1.5245              25796.4
STATSIONAR 4        14       100.99              3.37152             25669.8
   RIC              15       101.689             4.10993             25619.5
MARISAT 1           15       101.689             4.10993             25619.5
INTELSAT 4A         19.5     104.887             7.42564             25395.1
INTELSAT 4A F1      24.5     108.565             11.0857             25151.8
STATSIONAR 8        25       108.941             11.4494             25127.9
INTELSAT 4A F2      29.5     112.408             14.7014             24916.7
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MIAMI, FLORIDA

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  RTH STATION AT :  80    :   17.4    :    0  W      25   :   47.6   :   0   N
SATELLITE          NODE         AZIMUTH             ELEVATION            DISTANCE(MI)
ATS-3               69          155.354              57.3235               22784
GOES-1              75          167.987              59.2821               22722.1
SATCOM 4            83          186.208              59.7057               22709.2
COMSTAR 3           87          195.13               58.9377               22732.7
WESTAR 3            91          203.493              57.5676               22776.1
COMSTAR 2           95          211.105              55.6741               22839
WESTAR 4            99          217.895              53.3435               22920.8
ANIK A1             104         225.265              49.9482               23049
SMS-1               105         226.602              49.2172               23078
ANIK A2             106.5       228.526              48.0923               23123.5
ANIK B              109         231.535              46.1507               23204.5
ANIK A3             114         236.888              42.0653               23385.7
-CTS-               116         238.813              40.371                23464.9
SATCOM 2            119         241.501              37.7794               23590.5
WESTAR 5            123.5       245.146              33.8045               23793.3
COMSTAR 1           128         248.407              29.756                24011.9
SATCOM 3R           131         250.403              27.0302               24165.5
SATCOM 1            135         252.883              23.3749               24379.1
SMS-2               135         252.883              23.3749               24379.1
ATS-6               140         255.739              18.7887               24658.3
ATS-1               149         260.376              10.5433               25187.6
  ATSIONAR 10       170         BELOW YOUR HORIZON BY   8.41   DEGREES
  TELSAT 4 F4       181         BELOW YOUR HORIZON BY   19.41   DEGREES
MARISAT 2           183         BELOW YOUR HORIZON BY   21.41   DEGREES
INTELSAT 4 F8       186         BELOW YOUR HORIZON BY   24.41   DEGREES
STATSIONAR 7        220         BELOW YOUR HORIZON BY   58.41   DEGREES
-CS-                225         BELOW YOUR HORIZON BY   63.41   DEGREES
-ETS-               230         BELOW YOUR HORIZON BY   68.41   DEGREES
-BSE-               250         BELOW YOUR HORIZON BY   88.41   DEGREES
STATSIONAR T        261         BELOW YOUR HORIZON BY   72.8978   DEGREES
EKRAN 2             261         BELOW YOUR HORIZON BY   72.8978   DEGREES
EKRAN 1             261         BELOW YOUR HORIZON BY   72.8978   DEGREES
STATSIONAR 6        275         BELOW YOUR HORIZON BY   69.2588   DEGREES
PALAPA 1            277         BELOW YOUR HORIZON BY   68.2816   DEGREES
STATSIONAR 1        280         BELOW YOUR HORIZON BY   66.6538   DEGREES
PALAPA 2            283         BELOW YOUR HORIZON BY   64.857   DEGREES
MARISAT 3           287         BELOW YOUR HORIZON BY   62.2424   DEGREES
INTELSAT 4A F3      297         BELOW YOUR HORIZON BY   54.9036   DEGREES
INTELSAT 4 F1       298.6       BELOW YOUR HORIZON BY   53.6504   DEGREES
INTELSAT 4F6        300         BELOW YOUR HORIZON BY   52.54   DEGREES
INTELSAT 4 F5       300         BELOW YOUR HORIZON BY   52.54   DEGREES
STATSIONAR 5        302         BELOW YOUR HORIZON BY   50.9331   DEGREES
SYMPHONIE 1         311         BELOW YOUR HORIZON BY   43.4613   DEGREES
STATSIONAR 9        315         BELOW YOUR HORIZON BY   40.043   DEGREES
INTELSAT 4 F7       1           94.7046              .947449               25836.1
INTELSAT 4 F2       4           96.0594              3.65319               25650.6
SYMPHONIE 2         11.5        99.5846              10.4701               25192.4
   ATSIONAR 4       14          100.819              12.7564               25042.5
SIRIC               15          101.322              13.6714               24983.1
MARISAT 1           15          101.322              13.6714               24983.1
INTELSAT 4A         19.5        103.673              17.798                24720.2
INTELSAT 4A F1      24.5        106.479              22.3848               24438.4
STATSIONAR 8        25          106.773              22.8435               24410.8
INTELSAT 4A F2      29.5        109.545              26.9574               24169.7
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JACKSONVILLE, FLORIDA

W 30 : 29.6 : 0 N

SATELLITE	NODE	AZIMUTH	ELEVATION	DISTANCE(MI)
ATS-3	69	156.071	51.8557	22975.7
GOES-1	75	166.984	53.7243	22907.1
SATCOM 4	83	182.58	54.4431	22881.6
COMSTAR 3	87	190.379	53.9986	22897.3
WESTAR 3	91	197.904	53.0386	22931.9
COMSTAR 2	95	204.996	51.605	22985.2
WESTAR 4	99	211.557	49.7532	23056.7
ANIK A1	104	218.96	46.9449	23171
SMS-1	105	220.335	46.327	23197.1
ANIK A2	106.5	222.334	45.3684	23238.1
ANIK B	109	225.499	43.6955	23311.7
ANIK A3	114	231.257	40.1097	23477.3
-CTS-	116	233.366	38.5999	23550.2
SATCOM 2	119	236.342	36.2704	23666.1
WESTAR 5	123.5	240.432	32.6567	23854.1
COMSTAR 1	128	244.138	28.9335	24057.8
SATCOM 3R	131	246.428	26.4061	24201.4
SATCOM 1	135	249.289	22.9964	24401.7
SMS-2	135	249.289	22.9964	24401.7
ATS-6	140	252.605	18.6907	24664.5
ATS-1	149	258.022	10.8856	25165
STATSIONAR 10	170	BELOW YOUR HORIZON BY 7.00999 DEGREES		
INTELSAT 4 F4	181	BELOW YOUR HORIZON BY 18.01 DEGREES		
MARISAT 2	183	BELOW YOUR HORIZON BY 20.01 DEGREES		
INTELSAT 4 F8	186	BELOW YOUR HORIZON BY 23.01 DEGREES		
STATSIONAR 7	220	BELOW YOUR HORIZON BY 57.01 DEGREES		
-CS-	225	BELOW YOUR HORIZON BY 62.01 DEGREES		
-ETS-	230	BELOW YOUR HORIZON BY 67.01 DEGREES		
-BSE-	250	BELOW YOUR HORIZON BY 87.01 DEGREES		
STATSIONAR T	261	BELOW YOUR HORIZON BY 98.01 DEGREES		
EKRAN 2	261	BELOW YOUR HORIZON BY 98.01 DEGREES		
EKRAN 1	261	BELOW YOUR HORIZON BY 98.01 DEGREES		
STATSIONAR 6	275	BELOW YOUR HORIZON BY 65.6867 DEGREES		
PALAPA 1	277	BELOW YOUR HORIZON BY 64.913 DEGREES		
STATSIONAR 1	280	BELOW YOUR HORIZON BY 63.5915 DEGREES		
PALAPA 2	283	BELOW YOUR HORIZON BY 62.096 DEGREES		
MARISAT 3	287	BELOW YOUR HORIZON BY 59.8669 DEGREES		
INTELSAT 4A F3	297	BELOW YOUR HORIZON BY 53.3821 DEGREES		
INTELSAT 4 F1	298.6	BELOW YOUR HORIZON BY 52.2503 DEGREES		
INTELSAT 4F6	300	BELOW YOUR HORIZON BY 51.243 DEGREES		
INTELSAT 4 F5	300	BELOW YOUR HORIZON BY 51.243 DEGREES		
STATSIONAR 5	302	BELOW YOUR HORIZON BY 49.7782 DEGREES		
SYMPHONIE 1	311	BELOW YOUR HORIZON BY 42.88 DEGREES		
STATSIONAR 9	315	BELOW YOUR HORIZON BY 39.6874 DEGREES		
INTELSAT 4 F7	1	BELOW YOUR HORIZON BY .687103 DEGREES		
INTELSAT 4 F2	4	96.3187	1.90524	25770.3
SYMPHONIE 2	11.5	100.359	8.38748	25330.7
STATSIONAR 4	14	101.762	10.5556	25186.7
RIC	15	102.333	11.4235	25129.6
MARISAT 1	15	102.333	11.4235	25129.6
INTELSAT 4A	19.5	104.984	15.33	24876.5
INTELSAT 4A F1	24.5	108.115	19.6583	24604.5
STATSIONAR 8	25	108.441	20.0895	24577.9
INTELSAT 4A F2	29.5	111.492	23.9547	24344.7

ATLANTA, GEORGIA

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EARTH STATION AT :  84    :    25.7    :    0   W      3   :   38.3   :   0    N
  TELLITE              NODE         AZIMUTH               ELEVATION            DISTANCE(MI)
ATS-3                   69          102.949               71.3982               22421.3
GOES-1                  75          110.914               78.12                 22317.1
SATCOM 4                83          158.549               85.3978               22255.8
COMSTAR 3               87          215.29                84.7603               22259
WESTAR 3                91          241.152               81.1641               22284.9
COMSTAR 2               95          251.221               76.8597               22333.1
WESTAR 4                99          256.282               72.3689               22403.4
ANIK A1                 104         259.88                66.6795               22521.4
SMS-1                   105         260.403               65.5382               22548.9
ANIK A2                 106.5       261.105               63.826                22592.5
ANIK B                  109         262.099               60.9757               22671.5
ANIK A3                 114         263.619               55.2931               22852
-CTS-                   116         264.104               53.0307               22932.2
SATCOM 2                119         264.739               49.6503               23060.8
WESTAR 5                123.5       265.531               44.6155               23271
COMSTAR 1               128         266.184               39.6284               23500.4
SATCOM 3R               131         266.562               36.3315               23663
SATCOM 1                135         267.013               31.9738               23890.8
SMS-2                   135         267.013               31.9738               23890.8
ATS-6                   140         267.509               26.588                24190.9
ATS-1                   149         268.272               17.0733               24765.8
STATSIONAR 10           170         BELOW YOUR HORIZON BY    4.27166   DEGREES
INTELSAT 4 F4           181         BELOW YOUR HORIZON BY    15.2717   DEGREES
MARISAT 2               183         BELOW YOUR HORIZON BY    17.2717   DEGREES
  .TELSAT 4 F8          186         BELOW YOUR HORIZON BY    20.2717   DEGREES
STATSIONAR 7            220         BELOW YOUR HORIZON BY    54.2717   DEGREES
-CS-                    225         BELOW YOUR HORIZON BY    59.2717   DEGREES
-ETS-                   230         BELOW YOUR HORIZON BY    64.2717   DEGREES
-BSE-                   250         BELOW YOUR HORIZON BY    84.2717   DEGREES
STATSIONAR T            261         BELOW YOUR HORIZON BY    95.2717   DEGREES
EKRAN 2                 261         BELOW YOUR HORIZON BY    95.2717   DEGREES
EKRAN 1                 261         BELOW YOUR HORIZON BY    95.2717   DEGREES
STATSIONAR 6            275         BELOW YOUR HORIZON BY    87.5268   DEGREES
PALAPA 1                277         BELOW YOUR HORIZON BY    85.6209   DEGREES
STATSIONAR 1            280         BELOW YOUR HORIZON BY    82.7195   DEGREES
PALAPA 2                283         BELOW YOUR HORIZON BY    79.7879   DEGREES
MARISAT 3               287         BELOW YOUR HORIZON BY    75.8524   DEGREES
INTELSAT 4A F3          297         BELOW YOUR HORIZON BY    65.9483   DEGREES
INTELSAT 4 F1           298.6       BELOW YOUR HORIZON BY    64.3589   DEGREES
INTELSAT 4F6            300         BELOW YOUR HORIZON BY    62.9675   DEGREES
INTELSAT 4 F5           300         BELOW YOUR HORIZON BY    62.9675   DEGREES
STATSIONAR 5            302         BELOW YOUR HORIZON BY    60.9788   DEGREES
SYMPHONIE 1             311         BELOW YOUR HORIZON BY    52.0194   DEGREES
STATSIONAR 9            315         BELOW YOUR HORIZON BY    48.0337   DEGREES
INTELSAT 4 F7           1           BELOW YOUR HORIZON BY    2.14191   DEGREES
INTELSAT 4 F2           4           90.6131                 .86731              25841.7
SYMPHONIE 2             11.5        91.1164               8.44569               25326.8
STATSIONAR 4            14          91.2924               11.0058               25157.1
SIRIC                   15          91.3643               12.0346               25089.6
  RISAT 1               15          91.3643               12.0346               25089.6
INTELSAT 4A             19.5        91.7005               16.7086               24789.3
INTELSAT 4A F1          24.5        92.1043               21.953                24464.4
STATSIONAR 8            25          92.1468               22.482                24432.5
INTELSAT 4A F2          29.5        92.551                27.2768               24151.4
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NORTH CAROLINA

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EARTH STATION AT :  80    :   0   :   0  W      35  :   0  :  0  N
SATELLITE          NODE        AZIMUTH            ELEVATION        DISTANCE(MI)
ATS-3               69         161.279            47.6887           23140
GOES-1              75         171.327            49.0049           23086.5
SATCOM 4            83         185.221            49.2288           23077.5
COMSTAR 3           87         192.083            48.6713           23099.9
WESTAR 3            91         198.721            47.6887           23140
COMSTAR 2           95         205.04             46.3141           23197.6
WESTAR 4            99         210.977            44.5877           23272.2
ANIK A1             104        217.82             42.0029           23388.6
SMS-1               105        219.111            41.4359           23414.8
ANIK A2             106.5      220.999            40.5581           23456.1
ANIK B              109        224.021            39.025            23529.5
ANIK A3             114        229.623            35.7324           23693.5
-CTS-               116        231.71             34.344            23765.1
SATCOM 2            119        234.69             32.1966           23878.8
WESTAR 5            123.5      238.85             28.8548           24062.2
COMSTAR 1           128        242.686            25.3971           24259.9
SATCOM 3R           131        245.086            23.0439           24398.9
SATCOM 1            135        248.119            19.8585           24592.1
SMS-2               135        248.119            19.8585           24592.1
ATS-6               140        251.678            15.8239           24844.9
ATS-1               149        257.583            8.48078           25324.5
STATSIONAR 10       170        BELOW YOUR HORIZON BY  8.7  DEGREES
INTELSAT 4 F4       181        BELOW YOUR HORIZON BY  19.7  DEGREES
MARISAT 2           183        BELOW YOUR HORIZON BY  21.7  DEGREES
INTELSAT 4 F8       186        BELOW YOUR HORIZON BY  24.7  DEGREES
STATSIONAR 7        220        BELOW YOUR HORIZON BY  58.7  DEGREES
-CS-                225        BELOW YOUR HORIZON BY  63.7  DEGREES
-ETS-               230        BELOW YOUR HORIZON BY  68.7  DEGREES
-BSE-               250        BELOW YOUR HORIZON BY  88.7  DEGREES
STATSIONAR T        261        BELOW YOUR HORIZON BY  63.6878  DEGREES
EKRAN 2             261        BELOW YOUR HORIZON BY  63.6878  DEGREES
EKRAN 1             261        BELOW YOUR HORIZON BY  63.6878  DEGREES
STATSIONAR 6        275        BELOW YOUR HORIZON BY  61.0018  DEGREES
PALAPA 1            277        BELOW YOUR HORIZON BY  60.2694  DEGREES
STATSIONAR 1        280        BELOW YOUR HORIZON BY  59.0318  DEGREES
PALAPA 2            283        BELOW YOUR HORIZON BY  57.6412  DEGREES
MARISAT 3           287        BELOW YOUR HORIZON BY  55.5757  DEGREES
INTELSAT 4A F3      297        BELOW YOUR HORIZON BY  49.5596  DEGREES
INTELSAT 4 F1       298.6      BELOW YOUR HORIZON BY  48.5058  DEGREES
INTELSAT 4F6        300        BELOW YOUR HORIZON BY  47.5667  DEGREES
INTELSAT 4 F5       300        BELOW YOUR HORIZON BY  47.5667  DEGREES
STATSIONAR 5        302        BELOW YOUR HORIZON BY  46.1993  DEGREES
SYMPHONIE 1         311        BELOW YOUR HORIZON BY  39.7317  DEGREES
STATSIONAR 9        315        BELOW YOUR HORIZON BY  36.7246  DEGREES
INTELSAT 4 F7       1          96.3617            .306824           25880.3
INTELSAT 4 F2       4          98.1386            2.75435           25712
SYMPHONIE 2         11.5       102.731            8.89011           25297.2
STATSIONAR 4        14         104.326            10.9351           25161.7
   RIC              15         104.974            11.7519           25108.1
MARISAT 1           15         104.974            11.7519           25108.1
INTELSAT 4A         19.5       107.979            15.418            24870.8
INTELSAT 4A F1      24.5       111.515            19.4577           24616.9
STATSIONAR 8        25         111.881            19.8585           24592.1
INTELSAT 4A F2      29.5       115.306            23.4385           24375.3
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NEW YORK

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  RTH STATION AT :  73     :    46.7    :    0   W        40   :   38.4   :   0   N
SATELLITE          NODE        AZIMUTH                ELEVATION          DISTANCE(MI)
ATS-3               69         172.686                42.7636             23353.8
GOES-1              75         181.875                43.0042             23342.8
SATCOM 4            83         193.997                42.0682             23385.6
COMSTAR 3           87         199.836                41.0849             23431.2
WESTAR 3            91         205.451                39.7886             23492.7
COMSTAR 2           95         210.804                38.2056             23569.5
WESTAR 4            99         215.875                36.3675             23661.2
ANIK A1             104        221.809                33.7587             23795.8
SMS-1               105        222.943                33.2005             23825.2
ANIK A2             106.5      224.611                32.3426             23870.9
ANIK B              109        227.307                30.8601             23951.2
ANIK A3             114        232.399                27.726              24125.9
-CTS-               116        234.331                26.4173             24200.7
SATCOM 2            119        237.126                24.4045             24318.1
WESTAR 5            123.5      241.105                21.2894             24504.6
COMSTAR 1           128        244.857                18.0828             24702.4
SATCOM 3R           131        247.247                15.905              24839.8
SATCOM 1            135        250.316                12.9638             25029
SMS-2               135        250.316                12.9638             25029
ATS-6               140        253.988                9.24371             25273.7
ATS-1               149        260.251                2.48331             25730.6
STATSIONAR 10       170        BELOW YOUR HORIZON BY   14.9217   DEGREES
INTELSAT 4 F4       181        BELOW YOUR HORIZON BY   25.9217   DEGREES
MARISAT 2           183        BELOW YOUR HORIZON BY   27.9217   DEGREES
INTELSAT 4 F8       186        BELOW YOUR HORIZON BY   30.9217   DEGREES
STATSIONAR 7        220        BELOW YOUR HORIZON BY   64.9217   DEGREES
-CS-                225        BELOW YOUR HORIZON BY   69.9217   DEGREES
-ETS-               230        BELOW YOUR HORIZON BY   74.9217   DEGREES
-BSE-               250        BELOW YOUR HORIZON BY   94.9217   DEGREES
STATSIONAR T        261        BELOW YOUR HORIZON BY   57.5335   DEGREES
EKRAN 2             261        BELOW YOUR HORIZON BY   57.5335   DEGREES
EKRAN 1             261        BELOW YOUR HORIZON BY   57.5335   DEGREES
STATSIONAR 6        275        BELOW YOUR HORIZON BY   53.7207   DEGREES
PALAPA 1            277        BELOW YOUR HORIZON BY   52.9144   DEGREES
STATSIONAR 1        280        BELOW YOUR HORIZON BY   51.6008   DEGREES
PALAPA 2            283        BELOW YOUR HORIZON BY   50.1718   DEGREES
MARISAT 3           287        BELOW YOUR HORIZON BY   48.1049   DEGREES
INTELSAT 4A F3      297        BELOW YOUR HORIZON BY   42.2704   DEGREES
INTELSAT 4 F1       298.6      BELOW YOUR HORIZON BY   41.2636   DEGREES
INTELSAT 4F6        300        BELOW YOUR HORIZON BY   40.3687   DEGREES
INTELSAT 4 F5       300        BELOW YOUR HORIZON BY   40.3687   DEGREES
STATSIONAR 5        302        BELOW YOUR HORIZON BY   39.0689   DEGREES
SYMPHONIE 1         311        BELOW YOUR HORIZON BY   32.9564   DEGREES
STATSIONAR 9        315        BELOW YOUR HORIZON BY   30.127  DEGREES
INTELSAT 4 F7       1          101.414                4.32226             25605
INTELSAT 4 F2       4          103.491                6.57757             25452.2
SYMPHONIE 2         11.5       108.894                12.181              25080
   ATSIONAR 4       14         110.777                14.0294             24960
SIRIC               15         111.543                14.7651             24912.6
MARISAT 1           15         111.543                14.7651             24912.6
INTELSAT 4A         19.5       115.098                18.0422             24704.9
INTELSAT 4A F1      24.5       119.277                21.6008             24485.7
STATSIONAR 8        25         119.709                21.9507             24464.5
INTELSAT 4A F2      29.5       123.74                 25.0437             24280.6
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BANGOR, MAINE

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EARTH STATION AT :  70    :    0    :    0  W       45  :   0   :   0   N
SATELLITE           NODE          AZIMUTH          ELEVATION           DISTANCE(MI)
ATS-3                69           178.586          38.1736              23571.1
GOES-1               75           187.053          37.9427              23582.4
SATCOM 4             83           198.082          36.5846              23650.2
COMSTAR 3            87           203.382          35.4851              23706.1
WESTAR 3             91           208.496          34.1299              23776.3
COMSTAR 2            95           213.403          32.5416              23860.3
WESTAR 4             99           218.093          30.7457              23957.4
ANIK A1              104          223.648          28.2441              24096.5
SMS-1                105          224.719          27.713               24126.6
ANIK A2              106.5        226.301          26.8999              24173
ANIK B               109          228.872          25.5003              24253.9
ANIK A3              114          233.787          22.5573              24428
-CTS-                116          235.673          21.3333              24501.9
SATCOM 2             119          238.422          19.4528              24617.2
WESTAR 5             123.5        242.38           16.5493              24798.9
COMSTAR 1            128          246.162          13.565               24990
SATCOM 3R            131          248.597          11.5393              25122
SATCOM 1             135          251.751          8.80538              25302.9
SMS-2                135          251.751          8.80538              25302.9
ATS-6                140          255.567          5.3475               25535.3
ATS-1                149          BELOW YOUR HORIZON BY  .946129  DEGREES
STATSIONAR 10        170          BELOW YOUR HORIZON BY  18.7  DEGREES
INTELSAT 4 F4        181          BELOW YOUR HORIZON BY  29.7  DEGREES
MARISAT 2            183          BELOW YOUR HORIZON BY  31.7  DEGREES
INTELSAT 4 F8        186          BELOW YOUR HORIZON BY  34.7  DEGREES
STATSIONAR 7         220          BELOW YOUR HORIZON BY  68.7  DEGREES
-CS-                 225          BELOW YOUR HORIZON BY  73.7  DEGREES
-ETS-                230          BELOW YOUR HORIZON BY  78.7  DEGREES
-BSE-                250          BELOW YOUR HORIZON BY  98.7  DEGREES
STATSIONAR T         261          BELOW YOUR HORIZON BY  52.657  DEGREES
EKRAN 2              261          BELOW YOUR HORIZON BY  52.657  DEGREES
EKRAN 1              261          BELOW YOUR HORIZON BY  52.657  DEGREES
STATSIONAR 6         275          BELOW YOUR HORIZON BY  48.5559  DEGREES
PALAPA 1             277          BELOW YOUR HORIZON BY  47.7531  DEGREES
STATSIONAR 1         280          BELOW YOUR HORIZON BY  46.4615  DEGREES
PALAPA 2             283          BELOW YOUR HORIZON BY  45.0725  DEGREES
MARISAT 3            287          BELOW YOUR HORIZON BY  43.0831  DEGREES
INTELSAT 4A F3       297          BELOW YOUR HORIZON BY  37.5324  DEGREES
INTELSAT 4 F1        298.6        BELOW YOUR HORIZON BY  36.58  DEGREES
INTELSAT 4F6         300          BELOW YOUR HORIZON BY  35.7343  DEGREES
INTELSAT 4 F5        300          BELOW YOUR HORIZON BY  35.7343  DEGREES
STATSIONAR 5         302          BELOW YOUR HORIZON BY  34.5071  DEGREES
SYMPHONIE 1          311          BELOW YOUR HORIZON BY  28.7486  DEGREES
STATSIONAR 9         315          BELOW YOUR HORIZON BY  26.088  DEGREES
INTELSAT 4 F7        1            105.186          6.04168              25488.3
INTELSAT 4 F2        4            107.475          8.11636              25348.8
SYMPHONIE 2          11.5         113.428          13.2287              25011.8
STATSIONAR 4         14           115.499          14.9002              24904
   RIC               15           116.341          15.5625              24861.6
MARISAT 1            15           116.341          15.5625              24861.6
INTELSAT 4A          19.5         120.238          18.495               24676.6
INTELSAT 4A F1       24.5         124.794          21.6413              24483.2
STATSIONAR 8         25           125.264          21.948               24464.7
INTELSAT 4A F2       29.5         129.622          24.6369              24304.4
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DENVER, COLORADO

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EARTH STATION AT :  104    :   52.6    :    0  W     39   :   46.5   :   0   N
SATELLITE          NODE          AZIMUTH              ELEVATION            DISTANCE(MI)
ATS-3               69            131.495              31.0865               23938.8
GOES-1              75            138.078              34.6555               23748.9
SATCOM 4            83            147.887              38.7319               23543.7
COMSTAR 3           87            153.245              40.4055               23463.3
WESTAR 3            91            158.886              41.7722               23398.3
COMSTAR 2           95            164.776              42.8598               23349.4
WESTAR 4            99            170.86               43.5847               23316.7
ANIK A1             104           178.63               43.9783               23299.1
SMS-1               105           180.193              43.9873               23298.7
ANIK A2             106.5         182.536              43.9567               23300.1
ANIK B              109           186.429              43.7891               23307.6
ANIK A3             114           194.091              43.0233               23342
-CTS-               116           197.083              42.5627               23362.9
SATCOM 2            119           201.469              41.7146               23401.9
WESTAR 5            123.5         207.777              40.114                23477.1
COMSTAR 1           128           213.721              38.1571               23571.9
SATCOM 3R           131           217.471              36.6777               23645.5
SATCOM 1            135           222.206              34.5168               23756.1
SMS-2               135           222.206              34.5168               23756.1
ATS-6               140           227.713              31.5543               23913.4
ATS-1               149           236.589              25.6609               24244.5
STATSIONAR 10       170           253.477              10.3191               25202.4
INTELSAT 4 F4       181           261.019              1.94102               25767.8
  .RISAT 2          183           262.337              .415192               25872.8
INTELSAT 4 F8       186           BELOW  YOUR  HORIZON  BY   1.88921   DEGREES
STATSIONAR 7        220           BELOW  YOUR  HORIZON  BY   33.8233   DEGREES
-CS-                225           BELOW  YOUR  HORIZON  BY   38.8233   DEGREES
-ETS-               230           BELOW  YOUR  HORIZON  BY   43.8233   DEGREES
-BSE-               250           BELOW  YOUR  HORIZON  BY   63.8233   DEGREES
STATSIONAR T        261           BELOW  YOUR  HORIZON  BY   74.8233   DEGREES
EKRAN 2             261           BELOW  YOUR  HORIZON  BY   74.8233   DEGREES
EKRAN 1             261           BELOW  YOUR  HORIZON  BY   74.8233   DEGREES
STATSIONAR 6        275           BELOW  YOUR  HORIZON  BY   88.8233   DEGREES
PALAPA 1            277           BELOW  YOUR  HORIZON  BY   90.8233   DEGREES
STATSIONAR 1        280           BELOW  YOUR  HORIZON  BY   93.8233   DEGREES
PALAPA 2            283           BELOW  YOUR  HORIZON  BY   96.8233   DEGREES
MARISAT 3           287           BELOW  YOUR  HORIZON  BY   58.878  DEGREES
INTELSAT 4A F3      297           BELOW  YOUR  HORIZON  BY   57.4139   DEGREES
INTELSAT 4 F1       298.6         BELOW  YOUR  HORIZON  BY   56.9988   DEGREES
INTELSAT 4F6        300           BELOW  YOUR  HORIZON  BY   56.5976   DEGREES
INTELSAT 4 F5       300           BELOW  YOUR  HORIZON  BY   56.5776   DEGREES
STATSIONAR 5        302           BELOW  YOUR  HORIZON  BY   55.9648   DEGREES
SYMPHONIE 1         311           BELOW  YOUR  HORIZON  BY   52.3345   DEGREES
STATSIONAR 9        315           BELOW  YOUR  HORIZON  BY   50.3646   DEGREES
INTELSAT 4 F7       1             BELOW  YOUR  HORIZON  BY   19.3221   DEGREES
INTELSAT 4 F2       4             BELOW  YOUR  HORIZON  BY   17.0389   DEGREES
SYMPHONIE 2         11.5          BELOW  YOUR  HORIZON  BY   11.2948   DEGREES
STATSIONAR 4        14            BELOW  YOUR  HORIZON  BY   9.37402   DEGREES
   RIC              15            BELOW  YOUR  HORIZON  BY   8.60546   DEGREES
MARISAT 1           15            BELOW  YOUR  HORIZON  BY   8.60546   DEGREES
INTELSAT 4A         19.5          BELOW  YOUR  HORIZON  BY   5.14851   DEGREES
INTELSAT 4A F1      24.5          BELOW  YOUR  HORIZON  BY   1.31844   DEGREES
STATSIONAR 8        25            BELOW  YOUR  HORIZON  BY   .936516   DEGREES
INTELSAT 4A F2      29.5          99.4768              2.51088               25728.7
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SAN DIEGO, CALIFORNIA

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EARTH STATION AT :  117    :    11.2    :    0   W        32   :   44   :   0   N

SATELLITE           NODE        AZIMUTH           ELEVATION          DISTANCE(MI)

ATS-3                69         115.813           26.3349             24205.5
GOES-1               75         120.821           31.1296             23936.5
SATCOM 4             83         128.522           37.185              23620.1
COMSTAR 3            87         132.909           40.0027             23482.4
WESTAR 3             91         137.715           42.6345             23359.6
COMSTAR 2            95         142.976           45.035              23252.6
WESTAR 4             99         148.719           47.1573             23162.1
ANIK A1              104        156.573           49.3398             23073.1
SMS-1                105        158.229           49.7053             23058.6
ANIK A2              106.5      160.761           50.2052             23039
ANIK B               109        165.101           50.9051             23011.9
ANIK A3              114        174.121           51.766              22979.1
-CTS-                116        177.806           51.9007             22974
SATCOM 2             119        183.351           51.8721             22975.1
WESTAR 5             123.5      191.563           51.3137             22996.2
COMSTAR 1            128        199.455           50.1657             23040.5
SATCOM 3R            131        204.451           49.0983             23082.8
SATCOM 1             135        210.72            47.3396             23154.5
SMS-2                135        210.72            47.3396             23154.5
ATS-6                140        217.879           44.6757             23268.3
ATS-1                149        228.923           38.8771             23536.7
STATSIONAR 10        170        247.695           22.5418             24428.9
INTELSAT 4 F4        181        255.107           13.3412             25004.5
MARISAT 2            183        256.349           11.6547             25114.4
INTELSAT 4 F8        186        258.163           9.12374             25281.6
STATSIONAR 7         220        BELOW  YOUR  HORIZON  BY   21.5133   DEGREES
-CS-                 225        BELOW  YOUR  HORIZON  BY   26.5133   DEGREES
-ETS-                230        BELOW  YOUR  HORIZON  BY   31.5133   DEGREES
-BSE-                250        BELOW  YOUR  HORIZON  BY   51.5133   DEGREES
STATSIONAR T         261        BELOW  YOUR  HORIZON  BY   62.5133   DEGREES
EKRAN 2              261        BELOW  YOUR  HORIZON  BY   62.5133   DEGREES
EKRAN 1              261        BELOW  YOUR  HORIZON  BY   62.5133   DEGREES
STATSIONAR 6         275        BELOW  YOUR  HORIZON  BY   76.5133   DEGREES
PALAPA 1             277        BELOW  YOUR  HORIZON  BY   78.5133   DEGREES
STATSIONAR 1         280        BELOW  YOUR  HORIZON  BY   81.5133   DEGREES
PALAPA 2             283
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LOS ANGELES, CALIFORNIA

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EARTH STATION AT :  118    :    24.4    :    0   W      33   :   56.5   :   0   N

SATELLITE              NODE        AZIMUTH            ELEVATION          DISTANCE(MI)

ATS-3                   69         115.569            24.7912              24295.3
GOES-1                  75         120.553            29.5121              24025.5
SATCOM 4                83         128.149            35.482               23706.3
COMSTAR 3               87         132.442            38.2687              23566.4
WESTAR 3                91         137.119            40.8773              23441
COMSTAR 2               95         142.214            43.2693              23330.9
WESTAR 4                99         147.75             45.4007              23236.7
ANIK A1                 104        155.294            47.6257              23142.6
SMS-1                   105        156.883            48.0046              23127
ANIK A2                 106.5      159.311            48.5286              23105.7
ANIK B                  109        163.474            49.2762              23075.6
ANIK A3                 114        172.142            50.2687              23036.5
-CTS-                   116        175.695            50.4675              23028.8
SATCOM 2                119        181.063            50.5468              23025.7
WESTAR 5                123.5      189.07             50.1731              23040.2
COMSTAR 1               128        196.842            49.226               23077.7
SATCOM 3R               131        201.807            48.2959              23115.2
SATCOM 1                135        208.088            46.7183              23180.5
SMS-2                   135        208.088            46.7183              23180.5
ATS-6                   140        215.332            44.2704              23286.2
ATS-1                   149        226.639            38.8144              23539.7
STATSIONAR 10           170        246.124            23.0349              24399.4
INTELSAT 4 F4           181        253.854            14.0246              24960.3
  .RISAT 2              183        255.147            12.3678              25067.8
INTELSAT 4 F8           186        257.036            9.87903              25231.5
STATSIONAR 7            220        BELOW YOUR HORIZON BY   20.2933      DEGREES
-CS-                    225        BELOW YOUR HORIZON BY   25.2933      DEGREES
-ETS-                   230        BELOW YOUR HORIZON BY   30.2933      DEGREES
-BSE-                   250        BELOW YOUR HORIZON BY   50.2933      DEGREES
STATSIONAR T            261        BELOW YOUR HORIZON BY   61.2933      DEGREES
EKRAN 2                 261        BELOW YOUR HORIZON BY   61.2933      DEGREES
EKRAN 1                 261        BELOW YOUR HORIZON BY   61.2933      DEGREES
STATSIONAR 6            275        BELOW YOUR HORIZON BY   75.2933      DEGREES
PALAPA 1                277        BELOW YOUR HORIZON BY   77.2933      DEGREES
STATSIONAR 1            280        BELOW YOUR HORIZON BY   80.2933      DEGREES
PALAPA 2                283
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LOOK ANGLE CHART FOR SATCOM 3.

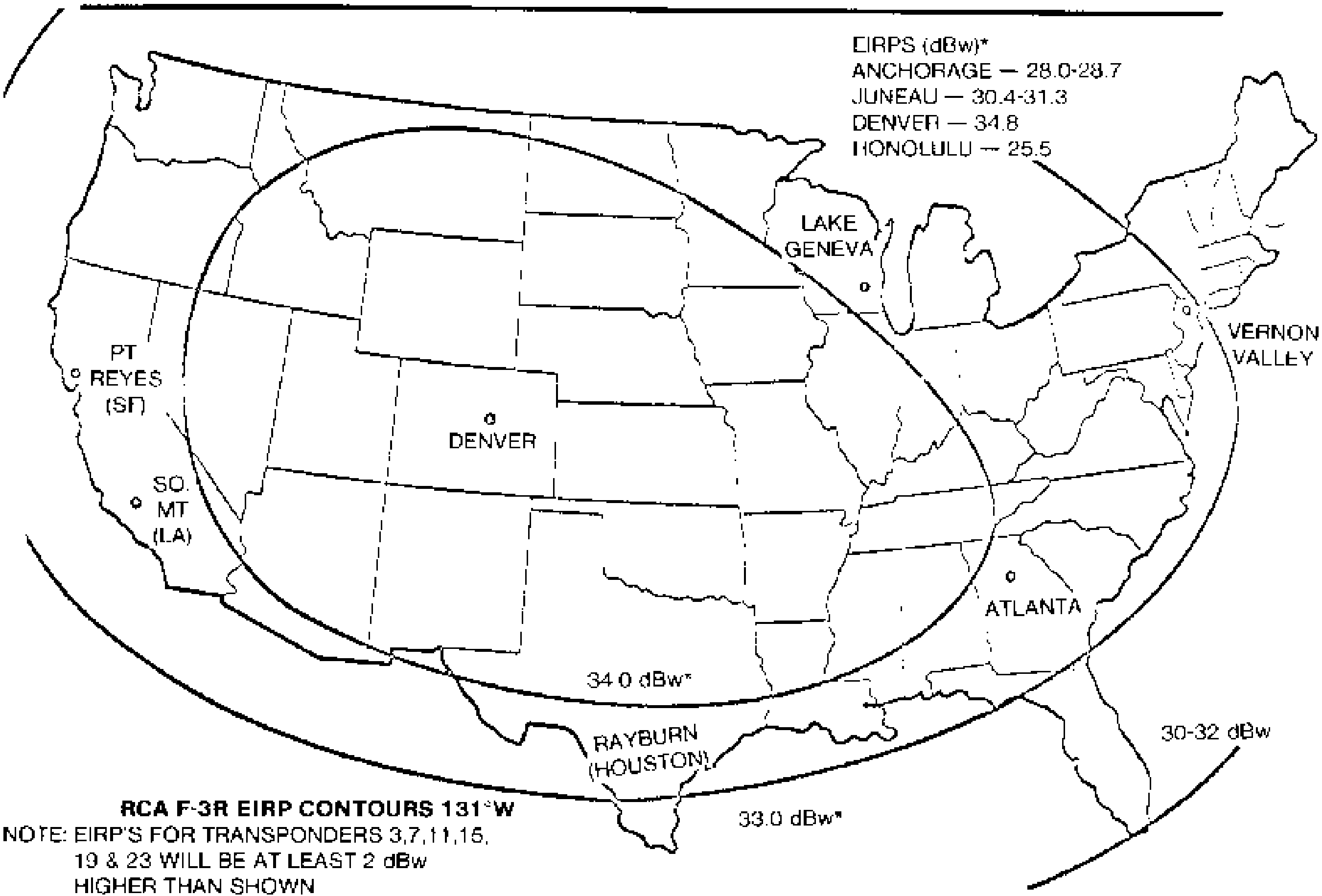
STATE	ELEVATION	AZIMUTH	POLARIZATION
Alabama	29	241	49
Arizona	45	213	31
Arkansas	33	232	42
Calif. N.	41	195	12
Calif. S.	46	200	19
Colorado	38	216	30
Connecticut	16	247	45
Delaware	19	246	47
Washington DC	19	246	47
Florida	27	248	57
Georgia	27	243	50
Idaho	37	204	19
Illinois	28	235	42
Indiana	26	238	43
Iowa	29	229	37
Kansas	34	225	36
Kentucky	24	240	44
Louisiana	34	238	50
Maine	9	249	41
Maryland	19	246	47
Massachusetts	15	246	42
Michigan	21	237	39
Minnesota	26	226	31
Mississippi	31	239	48
Missouri	31	231	42
Montana	32	209	22
Nebraska	31	222	33
Nevada	43	203	22
New Hampshire	13	248	43
New Jersey	16	247	45
New Mexico	43	222	34
New York	17	245	44
North Carolina	22	245	49
North Dakota	27	217	25
Ohio	23	239	42
Oklahoma	36	227	39
Oregon	39	194	11
Pennsylvania	19	243	43
Rhode Island	14	249	46
South Carolina	25	245	51
South Dakota	31	220	29
Tennessee	27	239	46
Texas N.	38	229	41
Texas W.	43	225	41
Texas E.	38	233	47
Texas S.	41	233	49
Utah	41	210	26
Vermount	15	246	42
Virginia	20	244	45
Washington	33	193	5
West Virginia	22	242	45
Wisconsin	24	233	37
Wyoming	34	214	26

LOOK ANGLE CHART FOR WESTAR 4.

STATE	ELEVATION	AZIMUTH	POLARIZATION
Alabama	49	202	21
Arizona	49	159	-20
Arkansas	48	189	8
Calif. N.	37	148	-26
Calif. S.	43	149	-28
Colorado	44	169	-10
Connecticut	36	216	28
Delaware	39	214	29
Washington DC	39	214	29
Florida	51	214	34
Georgia	47	206	25
Idaho	37	159	-16
Illinois	44	196	14
Indiana	43	200	17
Iowa	42	188	7
Kansas	45	180	0
Kentucky	42	204	22
Louisiana	53	195	15
Maine	29	219	27
Maryland	39	214	29
Massachusetts	34	214	26
Michigan	37	202	17
Minnesota	37	187	6
Mississippi	49	198	17
Missouri	45	188	7
Montana	33	167	-9
Nebraska	40	177	-3
Nevada	42	154	-23
New Hamoshire	33	217	28
New Jersey	36	216	29
New Mexico	50	167	-13
New York	37	212	26
North Carolina	43	212	28
North Dakota	34	177	-2
Ohio	40	202	19
Oklahoma	48	180	0
Oregon	35	149	-24
Pennsylvania	38	209	24
Rhode Island	35	218	30
South Carolina	46	210	28
South Dakota	40	180	0
Tennessee	46	201	19
Texas N.	51	180	0
Texas W.	53	171	-9
Texas E.	53	185	5
Texas S.	56	181	1
Utah	43	161	-17
Vermount	34	214	26
Virginia	40	211	25
Washington	30	151	-20
West Virginia	41	207	23
Wisconsin	39	195	12
Wyoming	39	170	-8

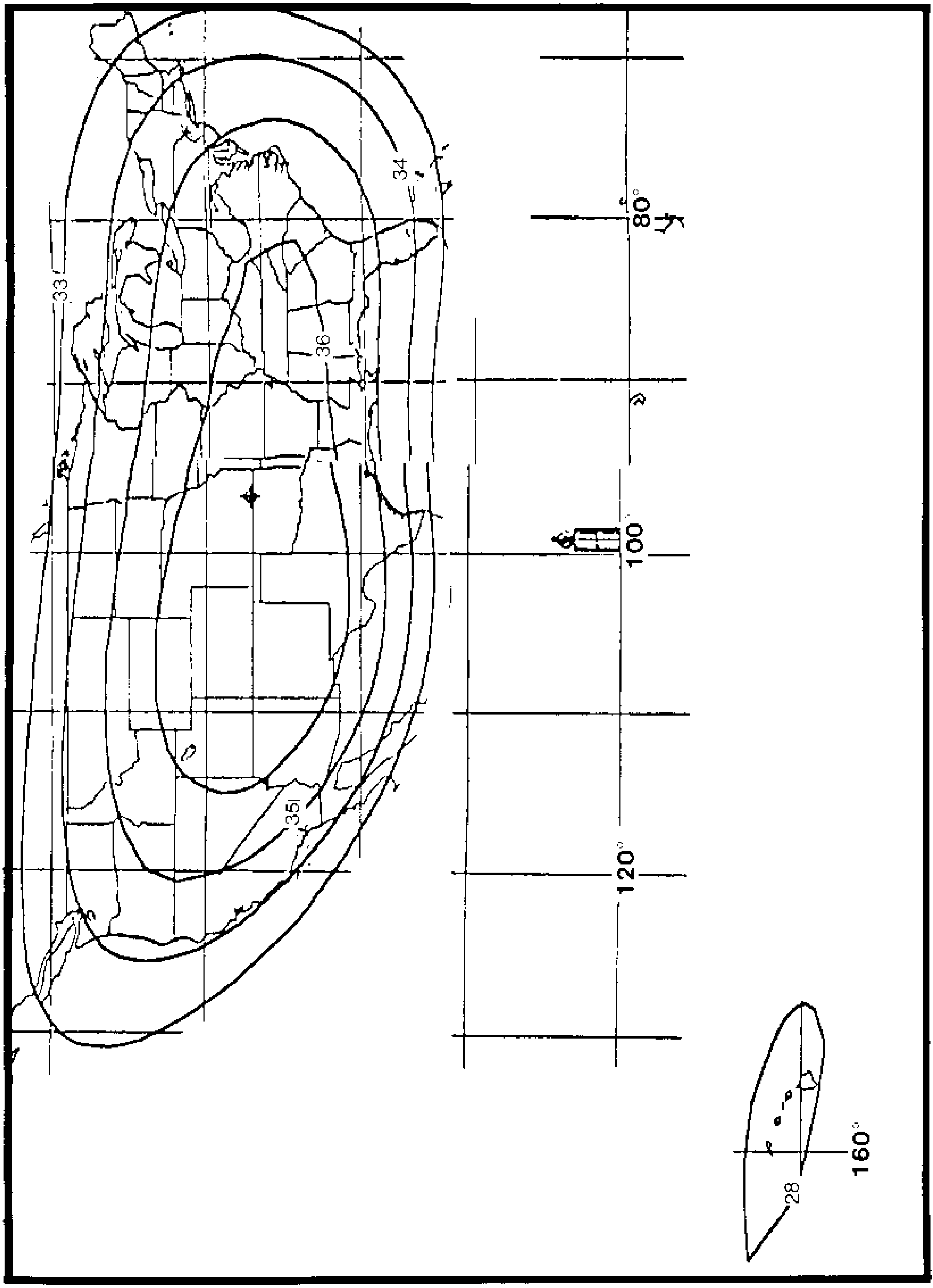
MAGNETIC VARIATION CHART FOR U.S.

STATE	VARIATION
Alabama	2E
Arizona	14E
Alaska	26E
Arkansas	6E
Calif. N.	17E
Calif. S.	16E
Colorado	14E
Connecticut	13W
Delaware	10W
Washington DC	8W
Florida	2E
Georgia	0
Idaho	19E
Illinois	2E
Indiana	0
Iowa	6E
Kansas	9E
Kentucky	1E
Louisiana	6E
Maine	20W
Maryland	8W
Massachusetts	15W
Michigan	3W
Minnesota	6E
Mississippi	5E
Missouri	6E
Montana	18E
Nebraska	11E
Nevada	17E
New Hampshire	16W
New Jersey	11W
New Mexico	13E
New York	10W
North Carolina	5W
North Dakota	11E
Ohio	3W
Oklahoma	9E
Oregon	20E
Pennsylvania	8W
Rhode Island	15W
South Carolina	2W
South Dakota	11E
Tennessee	1E
Texas	10E
Utah	15E
Vermount	15W
Virginia	6W
Washington	22E
West Virginia	5W
Wisconsin	2E
Wyoming	2E



RCA F-3R EIRP CONTOURS 131°W

NOTE: EIRP'S FOR TRANSPONDERS 3,7,11,15,
19 & 23 WILL BE AT LEAST 2 dBw
HIGHER THAN SHOWN


33
34
36
35I
28
80°
100°
120°
160°

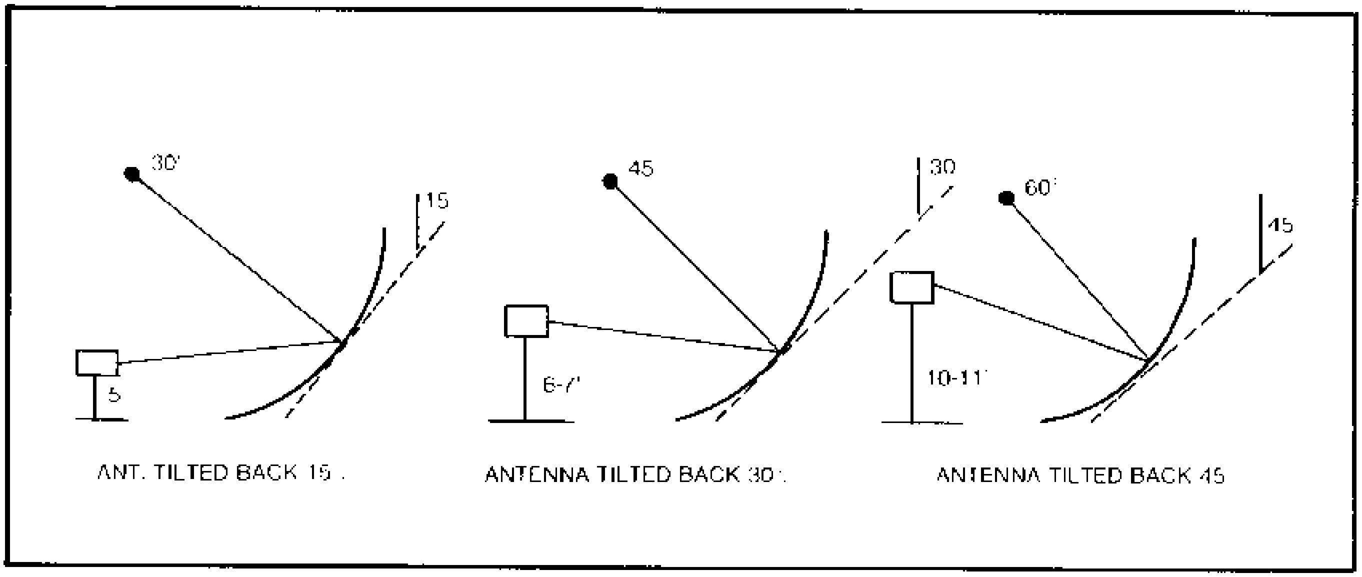
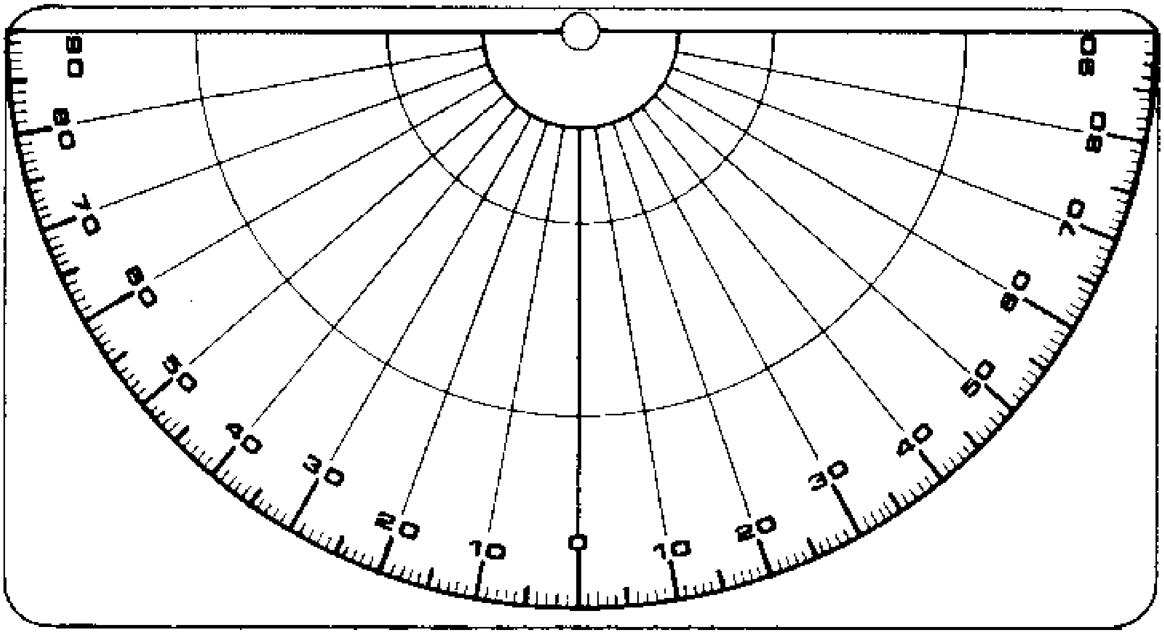
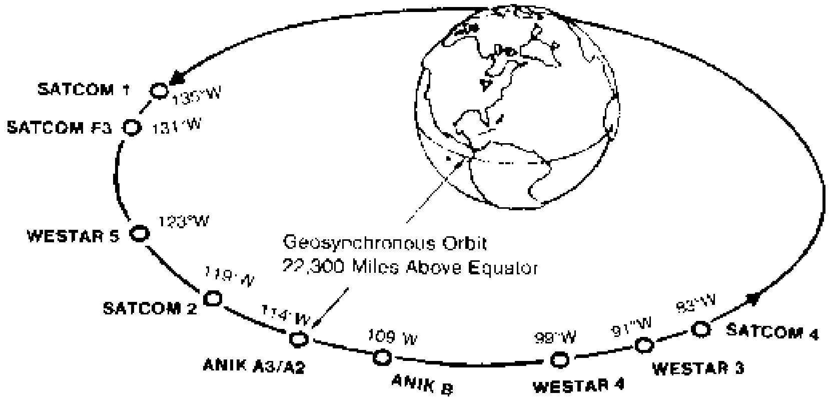

30°
15
5'
ANT. TILTED BACK 15°.
45
30
6-7'
ANTENNA TILTED BACK 30°.
60°
45
10-11'
ANTENNA TILTED BACK 45

FIGURE 3.3



SATELLITE PROGRAM GUIDE

CATV Format Transpndr No.	Frequency	Polarization w4-w5	Polarization w4	Satellite Transponder #'s		
				F3	F4	W4 W5
1	3720	V	H	1	1	1D
2	3740	H	V	2	2	1X
3	3760	V	H	3	3	2D
4	3780	H	V	4	4	2X
5	3800	V	H	5	5	3D
6	3820	H	V	6	6	3X
7	3840	V	H	7	7	4D
8	3860	H	V	8	8	4X
9	3880	V	H	9	9	5D
10	3900	H	V	10	10	5X
11	3920	V	H	11	11	6D
12	3940	H	V	12	12	6X
13	3960	V	H	13	13	7D
14	3980	H	V	14	14	7X
15	4000	V	H	15	15	8D
16	4020	H	V	16	16	8X
17	4040	V	H	17	17	9D
18	4060	H	V	18	18	9X
19	4080	V	H	19	19	10D
20	4100	H	V	20	20	10X
21	4120	V	H	21	21	11D
22	4140	H	V	22	22	11X
23	4160	V	H	23	23	12D
24	4180	H	V	24	24	12X



SATCOM F3

Tr.#	Video Service
1	NICKELODEON/ARTS
2	PTL
3	WGN
4	SPOTLIGHT
5	THE MOVIE CHANNEL
6	WTBS
7	ESPN
8	CBN
9	USA CABLE NETWORK/BET
10	SHOWTIME (WEST)
11	MTV
12	SHOWTIME (EAST)
13	HBO (WEST)
14	CNN
15	CNN2
16	HTN PLUS/ASCN/NJT
17	CBLE HEALTH NETWORK
18	EWTN/REUTERS
19	C-SPAN
20	CINEMAX (EAST)
21	THE WEATHER CHANNEL
22	MSN/DAYTIME/HBO
23	CINEMAX (WEST)
24	HBO (EAST)

SATCOM F4

Tr.#	Video Service
6	BRAVO
7	ESCAPADE. PLAYBOY/NCN
8	ENTERTAINMENT CHANNEL
17	TBN
18	HBO (E)*

WESTAR 4

Tr.#	Westar#	Video Service
6	3X	SIN
10	5X	SELECTV
29	10D	EROS
22	11X	SPN
24	12X	GALAVISION

WESTAR 5

Tr.#	Westar#	Video Service
3	2D	WOR-TV
7	4D	CBS CABLE
11	6D	SATELLITE NEWS CHANNEL
24	12X	BET

4.0) TOOLS AND MATERIAL.

There are two categories of tools involved with this project, those required and those that would make life easier during construction. First, a list of the required tools;

REQUIRED TOOLS

1-Saber saw
4-saw blades for above. Type is 3½ inches long, 7 teeth per inch
1-Corner square
1-12 foot or longer tape measure
1-Claw hammer
1-Hand drill
1-¼" drill bit
1-⅝" wood bit
1-Staple gun and 2000 ¼" staples
1-Felt tip pen
See photo 4.1

OPTIONAL TOOLS

1-Carpenter's level, 24"
1-¼" electric drill
1-Wood plane
4 sheets coarse sand paper
1-Inclinometer
See photo 4.2

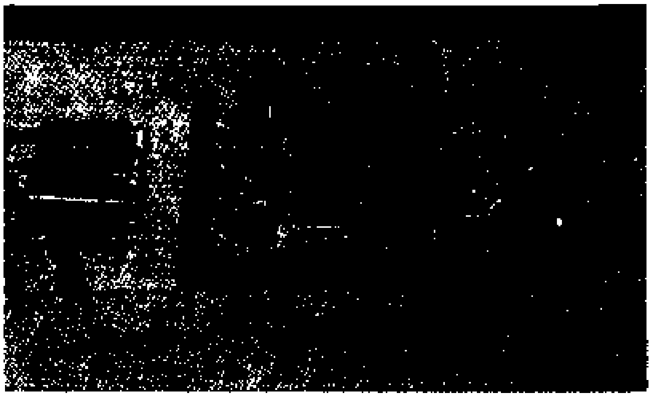


PHOTO 4.1

As we proceed through the construction of the antenna, it will become obvious why some of the tools in the optional list could make the project a little easier. Don't worry if you can't come up with the optional tools, you can still build a good antenna. You may be able to borrow most of the tools from a next door neighbor or friend, but I would suggest you buy the Saber saw as it will get an extraordinary workout on this project. You don't want to make your neighbor any madder than necessary as he is probably going to have to stare at this creation for a long time.

SOME CONSIDERATIONS ON THE MATERIAL USED.

The antenna we are going to build is a 12 footer, good enough for the continental U.S. If you live outside the U.S. or you just want to impress the neighbors you may decide to build the 14 through 20 footer. In that case, this list of materials will have to be adjusted for your antenna size. For those of you requiring large antennas, please read the section on BIG ANTENNAS. The rest of us can continue from here.

The cost of the wood will vary directly with the quality of the cut, the distance you are from the mill, and the mercenary nature of the lumber store owner. Based on these vagaries, the prices I am going to quote could be off a little bit!! But just keep in mind the great pictures you are going to get as you write the check and it might make it easier.

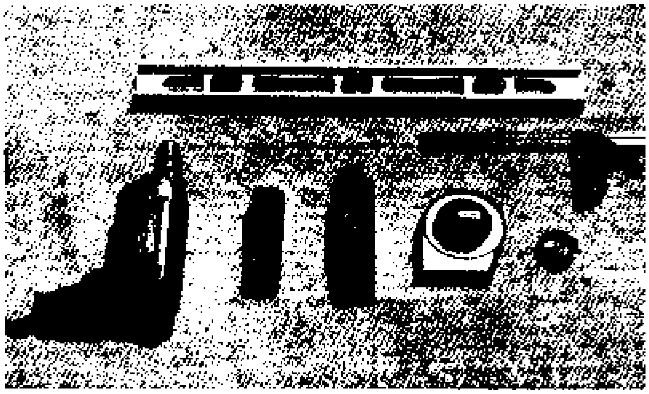


PHOTO 4.2

I purchased the bottom of the line mill cuts as we aren't building fine furniture here. The 1"x12"x12' are a #3 pine which means there will be a lot of knots in the board. The only way a knot will cause trouble is if it is in the middle of the board and it goes across most of the width. Most lumber stores will let you select your own lumber so it's up to you to find the good ones. Keep in mind that we will be cutting out the center six inches of the board so if a knot is in the right place we can make it go away. The 1"x18"x12' are a #2 pine so there are less knots per linear

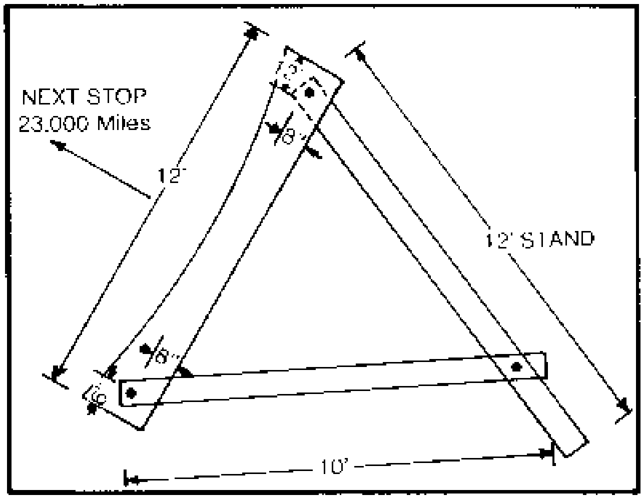


FIGURE 4.3

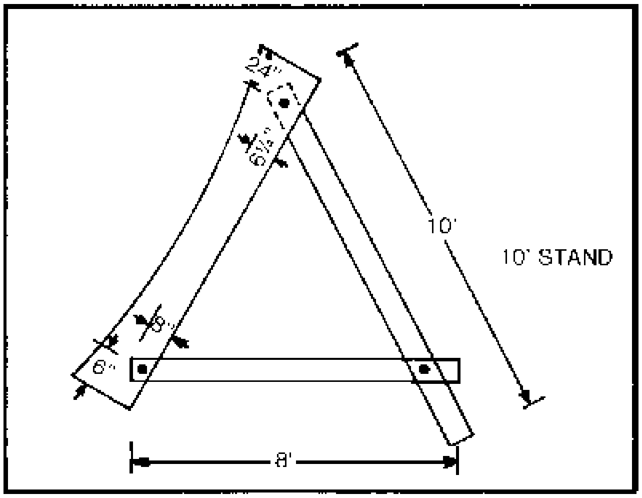


FIGURE 4.4

foot. It turns out that they don't make a #3 pine this wide or I would have bought those.

At this point you will have to make a decision on the width of the 4 pieces of lumber that make up the frame. Your choice is to reduce the width and make it cheaper or go with what I built. The 1"x18"x12' cost $25.00 each and the 1"x12"x12' cost $6.80 each. The price is linear between the 18", 16" and the 14". I wouldn't recommend you go any smaller than the 14" wide material. If you can afford it, I recommend the 18" wide material as it is the strongest.

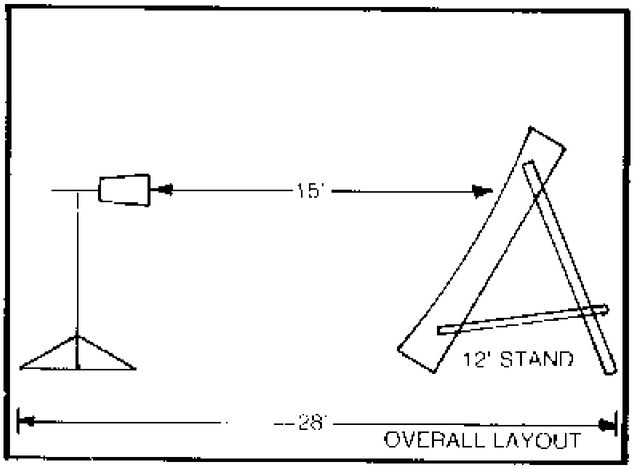


FIGURE 4.5

Also, you have to decide which frame stand is best for you. The full 12 foot stand is the strongest but it takes up a lot of room. I built the 12 foot stand first, then found out I could not fit it and the focal point stand in my back yard. Please see drawings 4.3, 4.4 and 4.5 for dimensions. I then came up with the smaller 10 foot stand and it fit fine. You can subtract about 4 to 5 feet from the base dimension in drawing 4.3 for the 10 foot stand. Okay, so much for all that, let's get on with the list of materials.

12 Foot Antenna Materials

4-1"x18"x12' #2 pine boards
19-1"x12"x12' #3 pine boards (you need 17, the other 2 are for mistakes.)
4-2"x4"x10'
6-rolls screen material, 26" wide, 12' long (fine mesh)
2-lbs. #6D nails
½ lbs. #10 nails
1-bottle white glue
1-roll of piano wire #26 or #28
1-roll of heavy string

12 foot stand.
4-2"x4"x12'
2-2"x4"x10'
2-2"x4"x20' (you can substitute 4 10' 2x4)

10 foot stand
2-2"x4"x12'
4-2"x4"x10'
2-2"x4"x18' (you can make the same substitution)

Hardware.
4-⅝" bolts, 3" long
2-⅝" bolts, 4" long
12-⅝" fender washers
6-⅝" nuts
35 feet #24 piano wire
1-3 inch spring

The total cost, if you go with the 18" wide material and the 12' stand, barring any mistakes, is less than $300.00. The total time required to construct this antenna, mount, feedhorn an feedhorn mount is 40 hours. Not bad for an antenna capable of providing sparkle free pictures on Satcom 3.

5.0) SCRIBING THE SPHERICAL CURVE ON THE WOOD.

If you remember the section on the comparison between a parabolic and spherical antenna you will remember that the spherical is a section cut out of a very big circle, in this case a circle 60 feet across. So, the radius is 30 feet which is the number we want to use right now. (See drawing 5.1 and photo 5.2 for the following discussion.) The intent of this section is to show you how to transfer a curved line onto a straight piece of wood. The curved line is that portion of the 60 foot circle that will soon be our antenna.

The easiest way I know to put this curved line on our boards is to make a giant protractor. As can be seen in the drawing we want to tie our piano wire to something slightly immovable and move away by 30 feet ± 2.0 inches, attach this wire to a pen, then drag it across the board hopefully making an accurate curve we can now cut out. The reason we want to use piano wire as opposed to regular wire is that piano wire will not stretch very easily and that fact will help us keep the curve correct. Accuracy is the key word here. I tried many different ways of scribing this curve and none but this last way were accurate enough. By the way, the accuracy we are striving for is + or - a 1/16 of an inch. This means that the line we are scribing shall not vary more than this amount. If we do a good job here we will be rewarded with excellent pictures later.

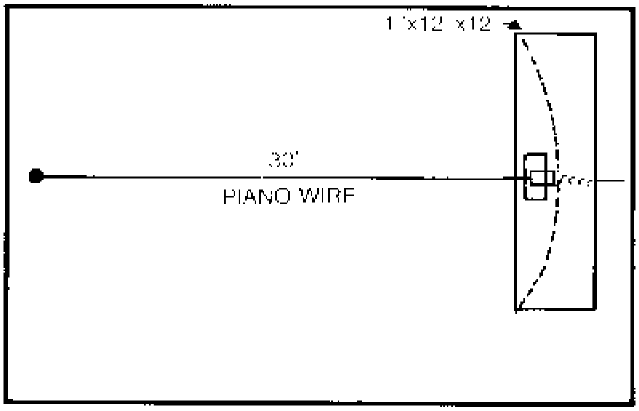


FIGURE 5.1

My answer to the problem of holding this tolerance was to build what I call a pen stabilizer (see figure 5.3 and photo 5.4). The stabilizer is supposed to allow you to move around while keeping the pen level and the tension on the piano wire constant. So construct something like what is shown in figure 5.3. Drill two ⅛" holes in the triangular piece about ½ inch in from each end and then nail the square piece of wood to triangular piece of wood. The dimensions are approximate and can vary depending on what scraps of wood you can find. The reason for the triangle

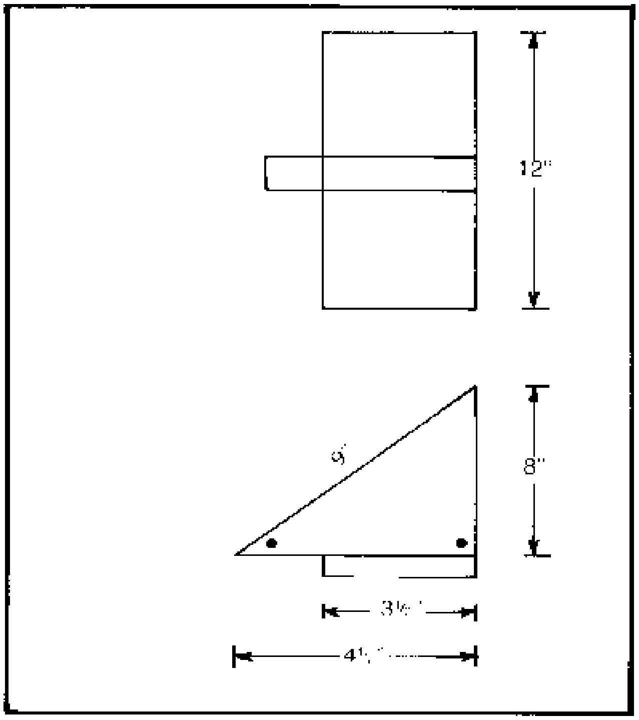


FIGURE 5.3

shape is to keep most the weight of the stabilizer on the pen which is attached to the straight side of the triangle. The pen is held in place by a couple of pieces of duct tape and the spring is attached to the wood by a piece of regular wire.

We are now ready to put pen to wood. Take each board to be cut and check its length, it should be 12 feet long. If it's too long cut it down now. If it's too short we can still use it. Most of mine were okay but I had to cut 4 or 5 of them down by a ¼ to ½ an inch.

PHOTO 5.2

Go find an area where you can set up a 30 foot long wire and a 12 foot board. Try to have this area be close to where you plan to cut out the ribs. You don't have to scribe all 17 boards in this manner, only enough until you come up with a wood form good enough to use as a master form. It took me 4 boards of practice until I got a form good enough to use on all future ribs. The ribs on the first 4 were okay for use on the antenna. I just didn't want to propigate the same error on all the rest of the ribs. By the time I had cut out all the ribs and sides I had 4 or 5 good forms. Practice makes perfect.

In my case, I used my front yard and tied the wire to the fence. Scribe a line across the board at the 6 foot point. Lay this board down on your giant protractor as in photo 5.4. Without a pen in

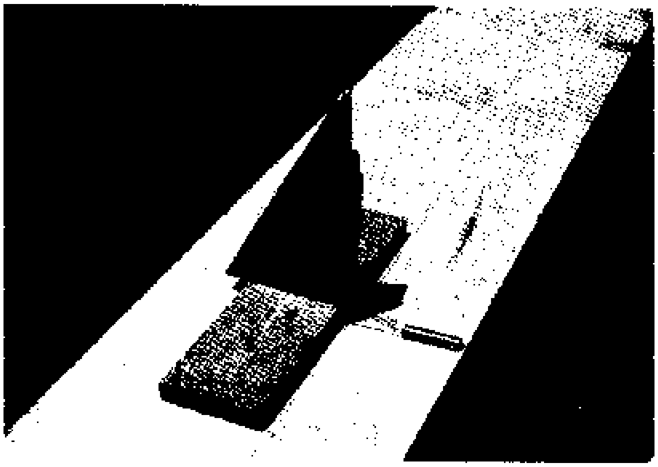


PHOTO 5.4

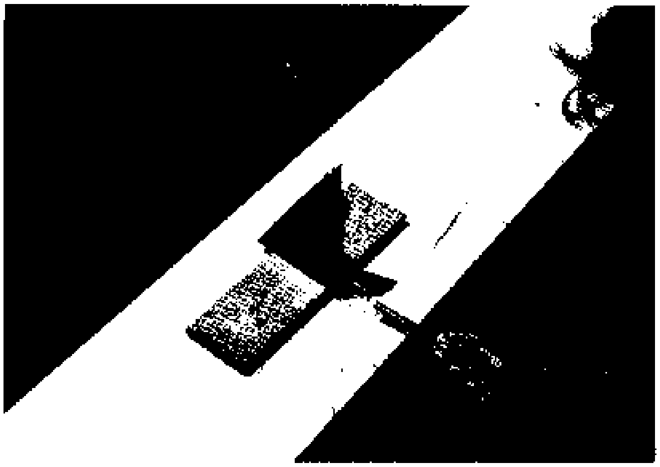


PHOTO 5.5

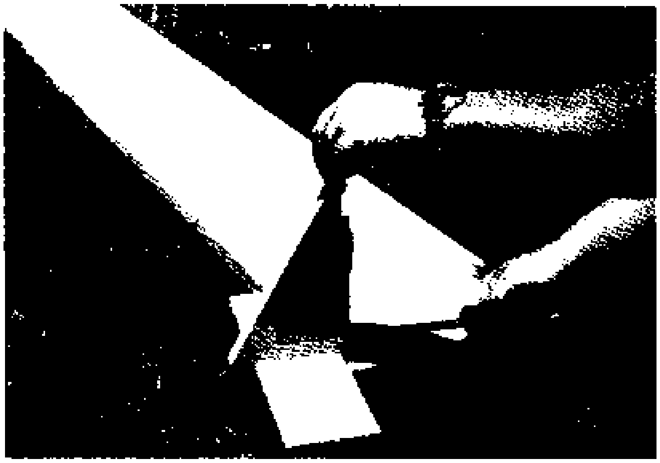


PHOTO 5.6

the stabilizer, run it back and forth across the board to get the feel of the spring and how much you can pull on it before the curve is affected. Attach the pen to the stabilizer, it should be touching the board but not so hard as to lift the stabilizer up. While holding the stabilizer just above the board, go to each end and make sure the pen crosses at the corner, as in photos 5.5, 5.6 and 5.7. You will have to go back and forth a few times while

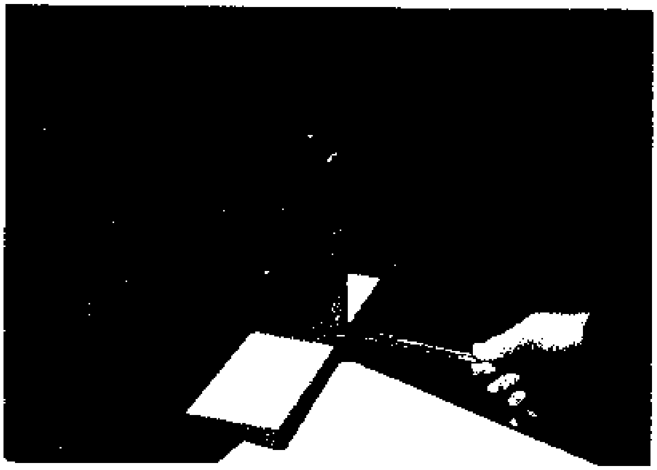


PHOTO 5.7

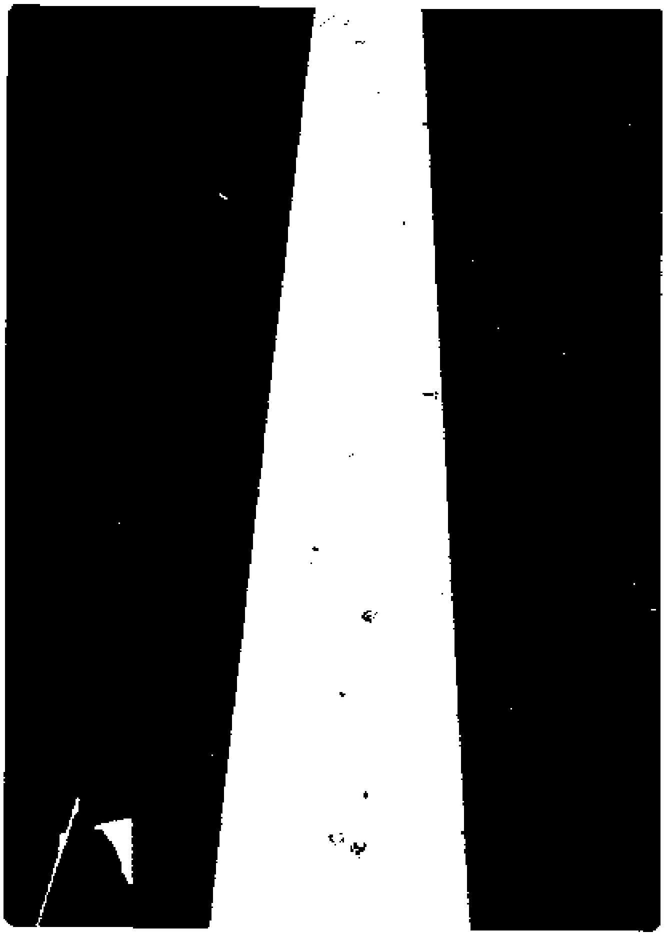


PHOTO 5.8

adjusting the position of the board to accomplish this, but it is important. If the curve is not symetrical, when we install the rib it will not fit the curve of the other ribs. When you are sure the curve is balanced on the board go back to the center and set the stabilizer down on the center line. Position yourself ½ the way between the center and the end you are going to first. Well, here we go, in one motion, without stopping, scribe the arc. Go to the middle again and position yourself ½ the way to the other end and have at it again. Well, how did you do? If you were like me, I fell over as I tried this the first time because I was not in a stable position. If you don't like what you see, turn the board around or turn it over and try again. Remember, you only have to do this till you get a good form, then you can just lay the form on the top of the board and trace around it. This and the next job are probably the most important tasks as they define the curve we call our antenna. Any big mistakes here and the antenna will not perform up to snuff. Take heart as I made lots of mistakes and the antenna still performed very well. I am not an expert in the art of wood working so I don't have any special dispensation for performing these unnatural acts. When you are satisfied with your results as in photo 5.8 you are ready to start cutting it out.

One side note, you could try scribing this arc on a piece of cardboard 12 feet long then take a pair of scissors and cut out the curve. Then use that to put the curve on the boards. I could not find a piece of cardboard this long to try this method out. If you try this, drop me a line to let me know how it worked. You will still need a good wood form to be used in the assembly of the antenna for checking the curve. This method would minimize the scurrying around on your hands and knees.

6.0) CUTTING OUT THE RIBS.

At this point it is assumed you have scribed a curve on a 1"x12"x12' pine board. I make the distinction between the ribs, 12" wide and the four sides, 18" wide. You do not want to practice on wood that cost $25.00 each. Save them for last after you have had a little practice. Locate the Saber saw you have procured and install a new blade that is 3½" long with 7 teeth per inch. If the blade is any finer than that it will take a lifetime to cut one board. If it's any coarser, the cut will be too rough and the saw will cut too fast leading to mistakes. After all, that's why you are following this manual, so you can avoid all the pitfalls I fell into.

Most Saber saws are adjustable as to the cutting angle. I want you to adjust your blade so it cuts at a 10 degree angle. (See photo 6.1) You will cut all but three of the ribs on this angle. The remaining three ribs will be cut flat, no angle.

The reason we are cutting on an angle is so the screen material will lay flat as it goes from rib to rib. The 3 flat ribs will be used in the center of the antenna where the curve changes direction (fig. 6.2 and photo 6.3)

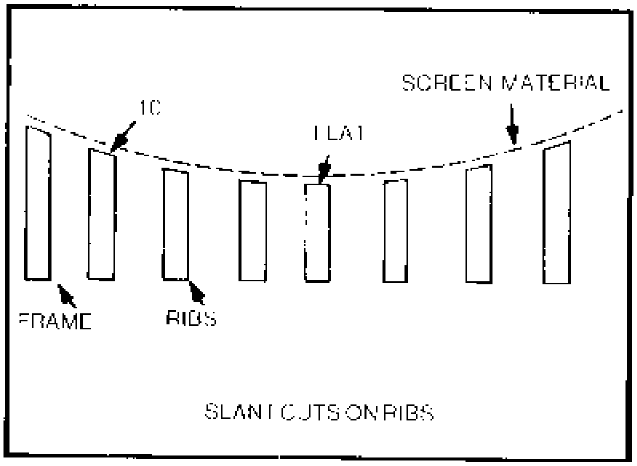


FIGURE 6.2

PHOTO 6.1

There are some basic safety rules to be adhered to when you fire up anything that can bite you. Wear safety glasses or goggles, keep track of your power cord and watch where you're cutting. I tried to cut my saw horse in half a couple of times. I found that a gentle pressure on the saw made for the best speed. If you push too hard the saw just cuts slower and that's non productive.

When you come to knots, you have to go very slowly, like 1/10 speed, or you will over-heat the saw and blade.

So let's get started, as in photo 6.4 and 6.4a, feed into the edge slowly and as soon as the saw base will sit flat on the board [illegible] so the 10 degree cut will occur.

PHOTO 6.3

The very first thing you will notice is that the sawdust tries to obscure the cutting line. I hope you have a good set of lungs as that's the way I kept the line clear. I always arrived at the end of a board breathless, not from the work, but from trying to follow the line.

I found the best way to follow the line with any precision was to add pressure to one side or the other to make the saw turn rather than actually turning the saw. I also found that once I started I was better off going all the way through before stopping. You will find that when you hit a knot the saw will try to turn away from it, taking the path of least resistance. This is where I found I made the biggest deviations from the curve. I learned quickly to anticipate the problem and lean into the knot to better hold the line. (photo 6.5 here)

PHOTO 6.4

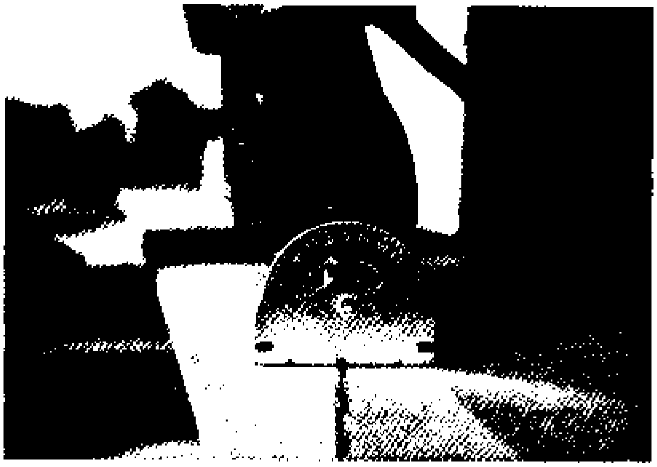


PHOTO 6.4A

After you have cut out a couple of ribs you will come up with a good form. Then go back to the ribs you have just cut out and use the form as a model and take off the rough edges with the hand plane or sandpaper. Photo 6.6 shows a form up against a newly cut out rib to check out the curve. You want to smooth out the curve, not change it, so go easy with the wood removal at this point. I had a couple of ribs I had to really work on to get them to be within the ¼ inch we are trying to hold. By the way, the best way to determine if a form is good enough to use for the rest of the ribs is to lay it down on a board that has the scribed curve. If it doesn't deviate from the line by more than ⅛ inch you can use it. Photo 6.7.

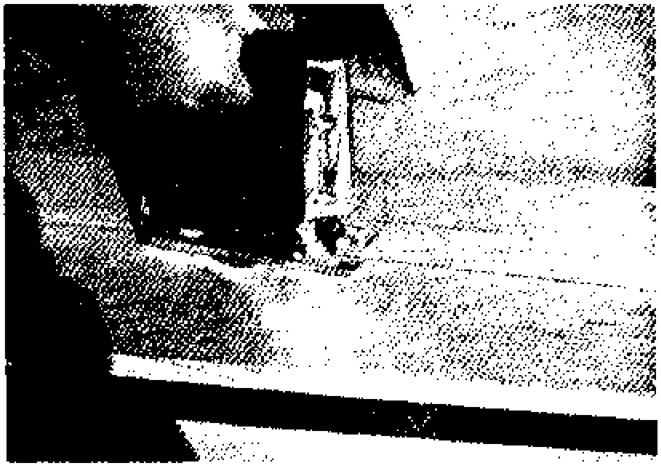


PHOTO 6.5

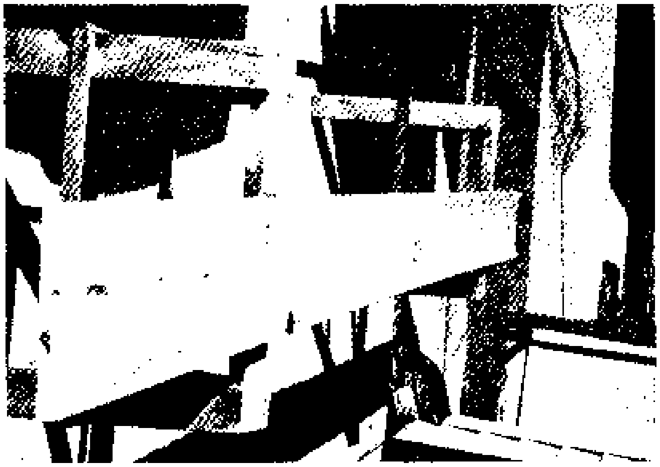


PHOTO 6.7

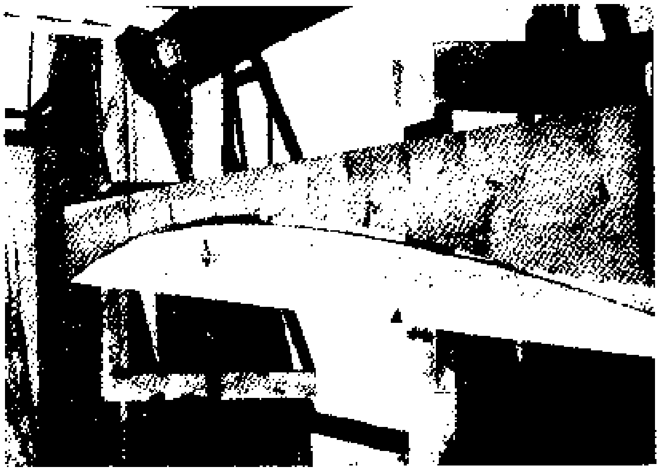


PHOTO 6.6

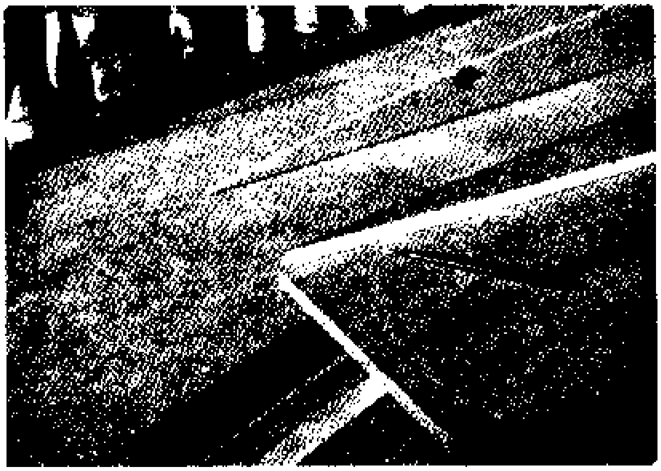


PHOTO 6.8

Now that you don't have to use the giant protractor to get the curve on the boards, life gets a little easier and the cutting will go a little faster. I set a schedule of cutting out 3 ribs a night, so one week later, they were all done. No sense making this any harder than it has to be. One last word on using the wood form to draw the curve on the rest of the boards. Make sure the form is cutting the corners the same on each end (photo 6.8). Don't fall into the trap I did and try to use the flat side of the form and the flat side of the board to line up by, my form's side was not straight. Oh well, it turned out that after all the cutting was over I went back over each rib and compared it to the form for best fit. After doing this I threw away 2 ribs as being too far gone to be used. Also during the assembly I busted one rib, so I ended up making 3 new ribs. But by this time, I was an expert at cutting out curved lines.

If you find some good forms as you're cutting out the ribs, set them aside for use during the antenna assembly. Also, a friend may want to build this antenna and you could save him/her a lot of trouble if you give them a good rib form.

At this point all the ribs have been cut out so the next step is to water-seal them to make them last as long as possible. You don't want to go to all this trouble and then have it rot away a year later. For want of a nail and all that.

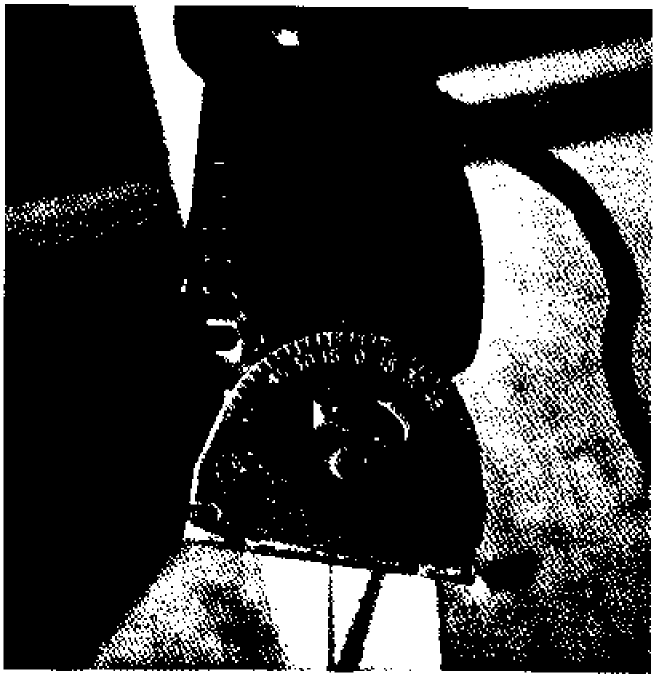
Now the fun really starts!

7.0) PREPARING THE FOUR SIDES FOR FINAL ASSEMBLY.

At this point you should have a pile of wood much like that shown in photo 7.1, all cut out and ready for assembly. Take the four 18" wide boards that will make up the frame and set them aside. Two of them will be the top and bottom and the other two the sides. For the two that are going to be the sides, you will want to mark them at the 6 foot point on both sides of the board, and then set them aside. The top and bottom will have to be marked from one end to the other on 8 inch centers, as shown in photo 7.2. You will want to mark both sides of the board so you will know where to place the nails for holding the ribs in place. These lines are where the ribs will be installed at a later time. Make sure that you start marking from the same end on both boards.

You should have cut the four sides on a 10 degree angle. If you did this, the angle should be leaning toward the center of the antenna. On the side that will be the inside of the antenna we will now install four 2x4 braces.

Cut four 2x4's 15 inches long from one of the 10 foot 2x4's. Find the #6 nails, the hammer and the glue. On all four braces start a couple of nails. The braces will be nailed to each end of the so called top and bottom frame boards. (Photo 7.3, 7.4) Measure in ¾ of an inch from each end and draw a line. This is



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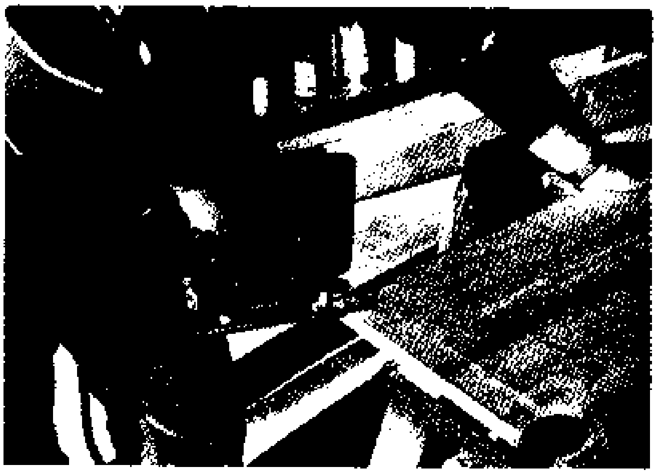
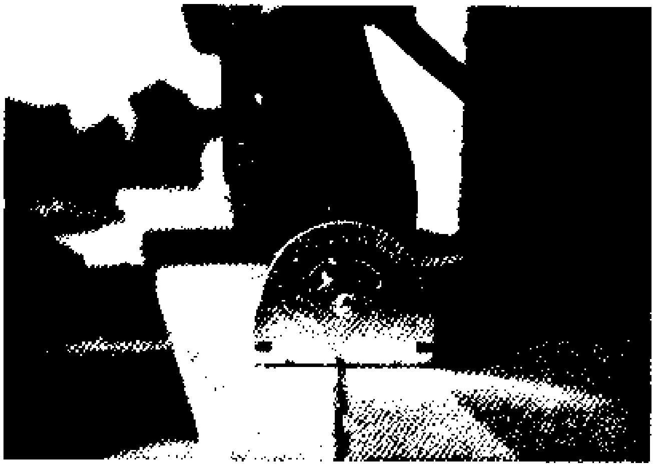


PHOTO 6.4



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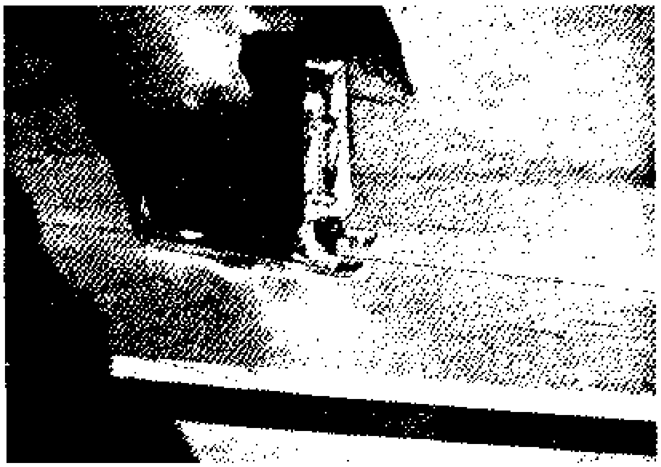


PHOTO 6.5

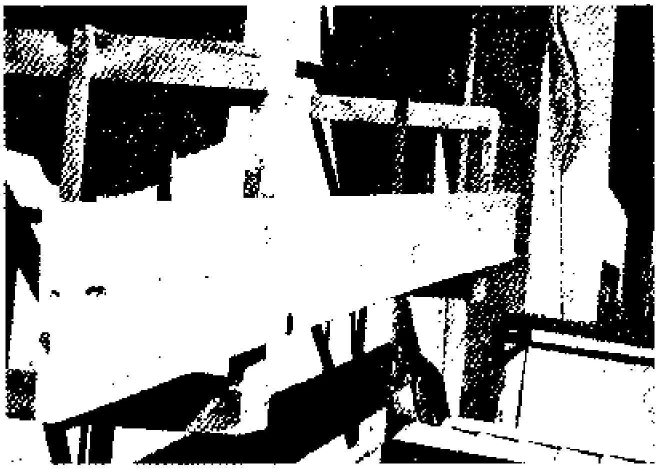


PHOTO 6.7

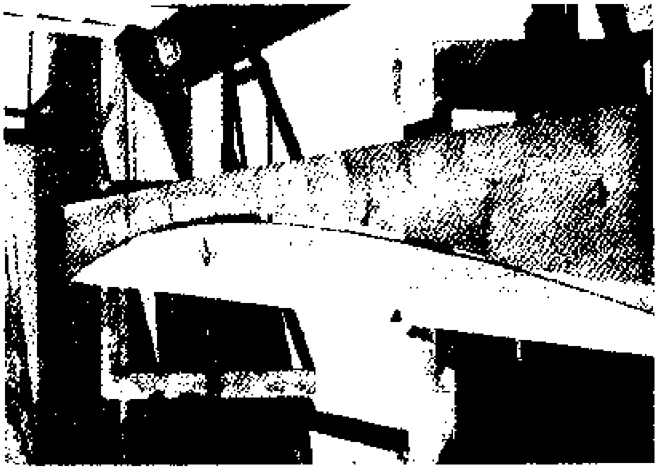
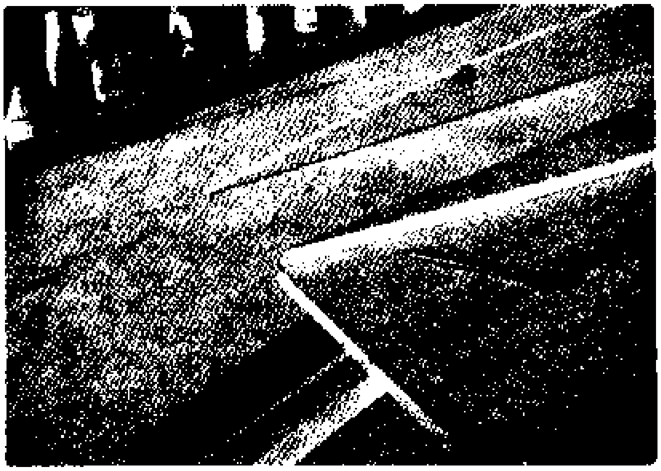


PHOTO 6.6



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Now that you don't have to use the giant protractor to get the curve on the boards, life gets a little easier and the cutting will go a little faster. I set a schedule of cutting out 3 ribs a night, so one week later, they were all done. No sense making this any harder than it has to be. One last word on using the wood form to draw the curve on the rest of the boards. Make sure the form is cutting the corners the same on each end (photo 6.8). Don't fall into the trap I did and try to use the flat side of the form and the flat side of the board to line up by. My form's side was not straight. Oh well, it turned out that after all the cutting was over I went back over each rib and compared it to the form for best fit. After doing this I threw away 2 ribs as being too far gone to be used. Also, during the assembly I busted one rib, so I ended up making 3 new ribs. But by this time, I was an expert at cutting out curved lines.

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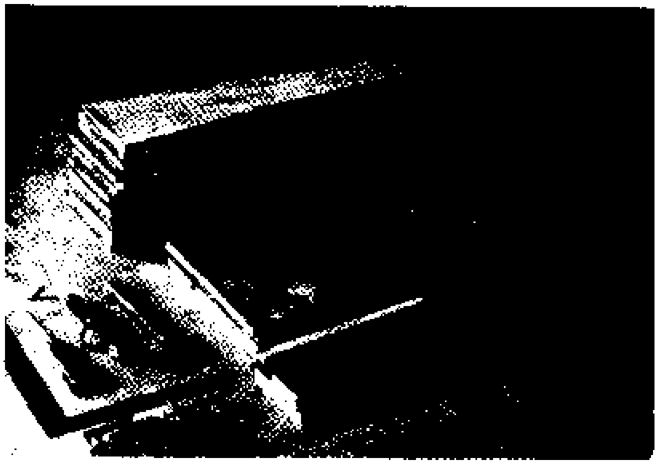


PHOTO 7.1

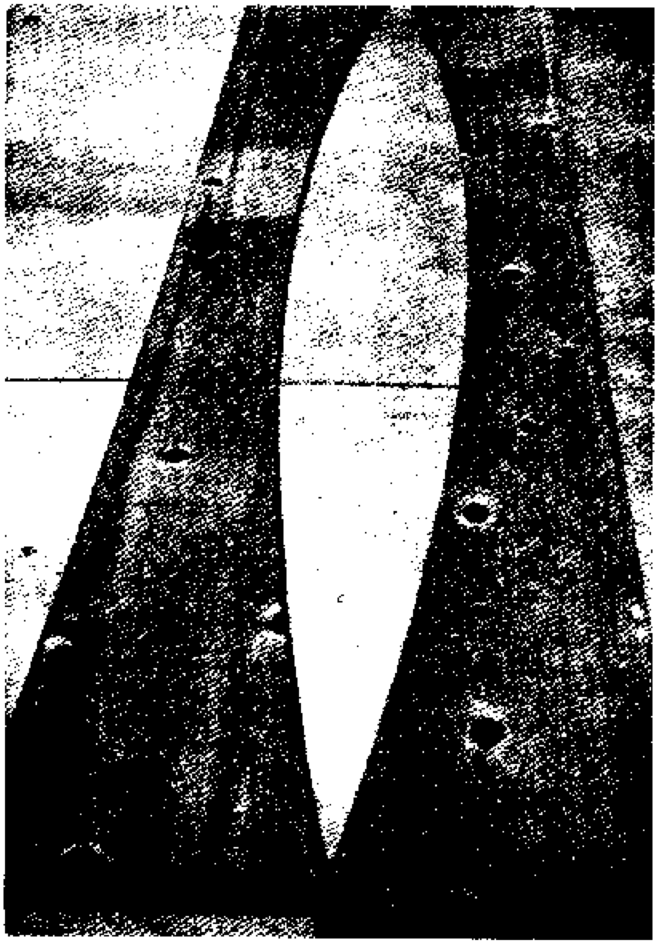


PHOTO 7.2

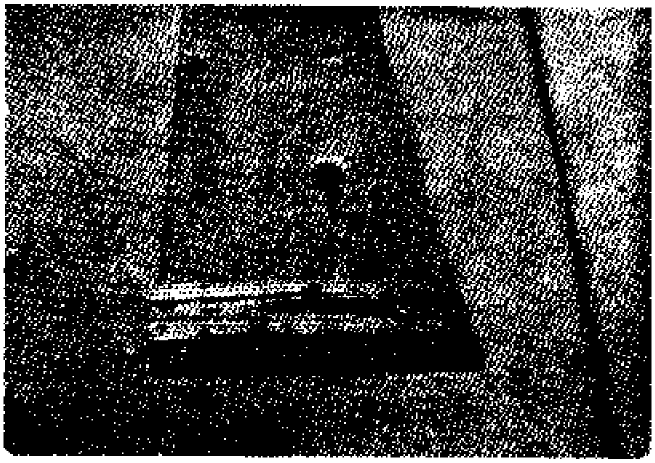


PHOTO 7.3

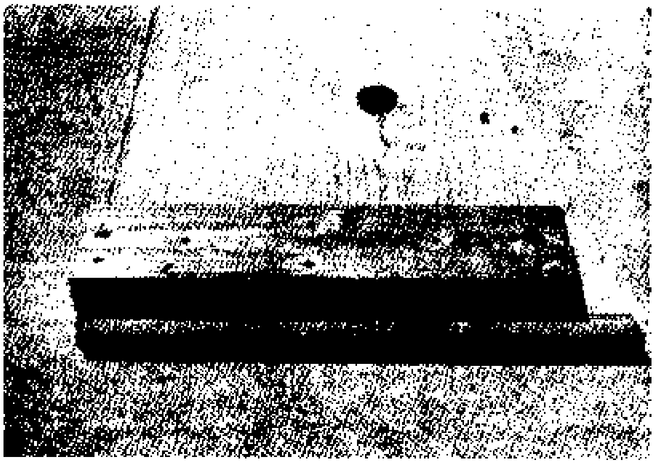


PHOTO 7.4

where the brace starts. Smear some glue on the 2x4 and then lay it down on the line flush with the uncut side of the board. Nail the brace to the board, taking care to make sure it doesn't move as you bash the nails in. Repeat the above procedure 3 more times and that's done.

These braces will be used to add as much strength to the four corners of the antenna as possible. A square is not all that strong in the corners so I added this brace as well as one more to give it as much help as possible. I had nightmares that as I tried to raise the structure it would come crashing down around my ears, hence the extra braces.

8.0) ASSEMBLING THE FOUR SIDES.

This is the beginning of the real antenna. From here on the structure will look more and more like the final product, so take heart it will get done.

Try to assemble the antenna in the same place where it will be used. You don't want to move it any further than necessary. First, it's heavy and moving it could stretch the metal screening that makes up the reflective surface. Also, it will help if the plot of ground you use for assembling the antenna is as flat as possible.

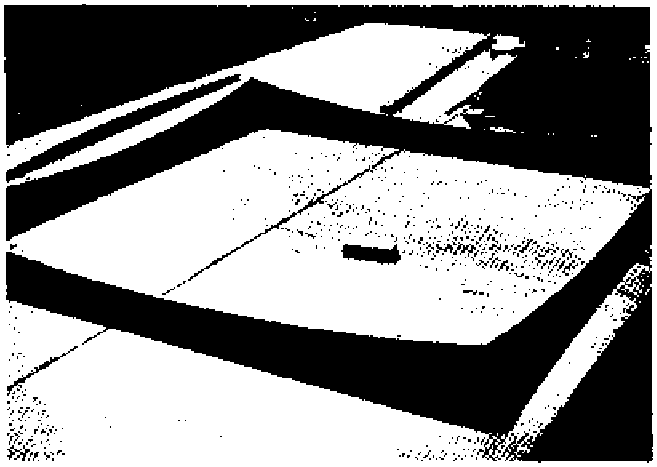


PHOTO 8.1

As you can see in photo 8.1, I assembled the antenna on a concrete pad I had put down for all my antennas.

Now that we've got all that out of the way, let's get started. Laid my antenna out on the ground in such a manner that when I raised it, it was pointing at the satellite of interest. This meant that the top and bottom were pointing north and south, for my location. You might want to consult section 3.0 for the satellite chart that comes closest to your location.

So, as you stand in front of your soon to be antenna, the lumber at the top and bottom have lines drawn on them every 8 inches and the 2x4 braces will be facing in. Select any corner to start and stand them up and tack two #6 nails through the 1x8 into the 2x4 brace. Don't drive the nail all the way in just yet, we are just getting the sides lined up and you may want to move them up or down for best fit.

The two curved surfaces should be flush in the corner where they meet. You can put the corner square into this new corner to make sure they are at right angles to each other. Go on to the rest of the corners and do the same thing. When you get done it should look like photo 8.1.

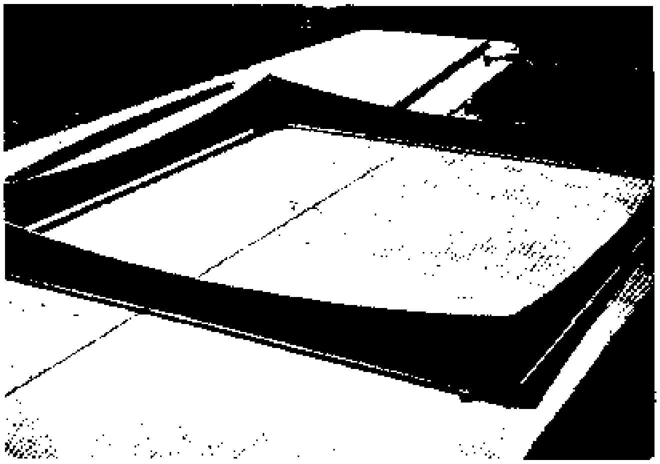


PHOTO 8.2

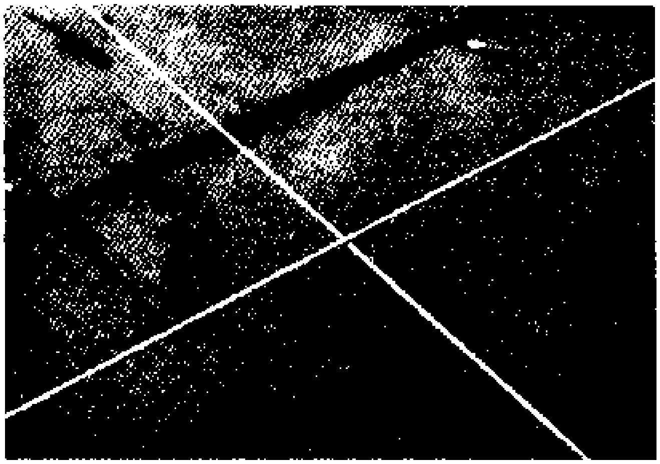


PHOTO 8.3

The structure is just tacked together so we can move the sides up and down in relation to each other. Find some string and staple it across the sides at the half way point(6'). (Photo 8.2) Pull the string very tight so you can see how close they cross each other, pry out the nails on the side that is out of position and move it into the right place, then retack it. I put my antenna up on a set of 2x4's so I could move the sides up and down to get the strings to just touch, as in photo 8.3. The purpose of the strings is to get the curves lined up with each other as closely as possible. When we add the center rib and the two end ribs we will be better able to set the position of the sides.

9.0) THE SMALL MIDRIB BRACE.

In the center of each rib a small 2x4 brace 7½ inches long is added for extra strength. Now you find out why you marked each rib at the 6 foot point. As you can see in figure 9.1 and photo 9.1a the braces will be installed back and forth across the center line. The reason for installing the braces in this manner is so you can nail into each of them after installing the rib. You can start on either side of the center line, it doesn't matter. Photo 9.2 shows the first brace installed on the low side of the center line.

You put a 10 degree slant on all but three of the ribs as you were cutting them out, you will have to make sure that the rib is facing in the right direction when we install the midrib brace. The slant should follow the curve that's been cut on the top and bottom frame boards. With this in mind we want to add a brace to the first rib.

For now on I will assume that as you stand in front of the antenna the board closest to you is the bottom and across from it is the top. The antenna will be assembled from left to right. I do not recommend you cut all the braces at once as you might want to lengthen or shorten them as you go. I found that the spacing varied about ¼ of an inch. After I had installed a few ribs and braces, I had to change the length on one brace to get the spacing back to 7½ inches. You can push the ribs back and forth a little to fit the brace out when it gets off by more than ¼ inch, put in a different length brace to get the spacing back in line. Select

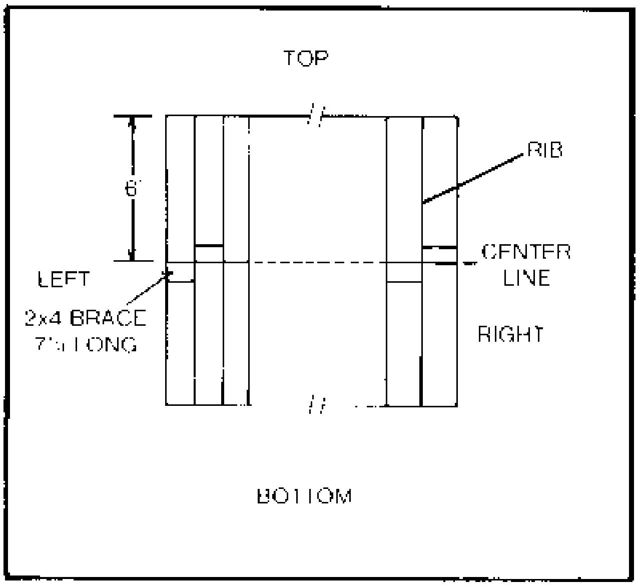


FIGURE 9.1

PHOTO 9.1A

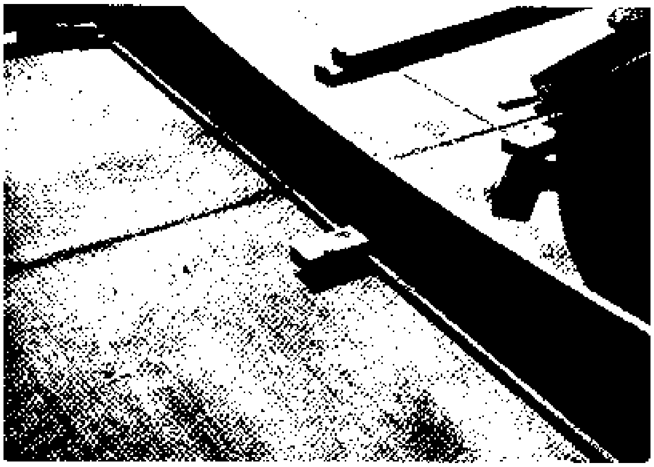


PHOTO 9.2

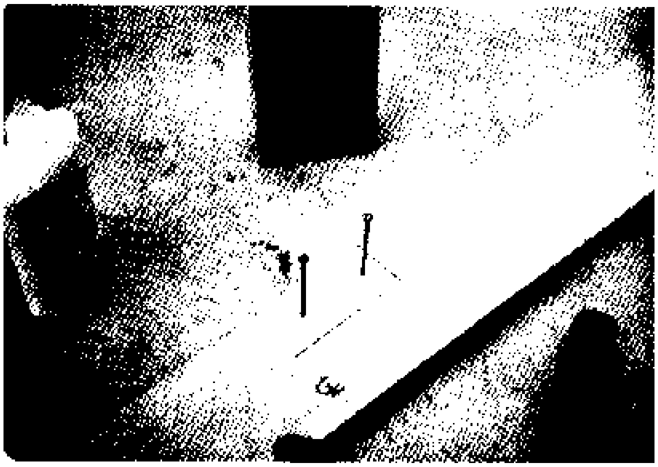


PHOTO 9.3

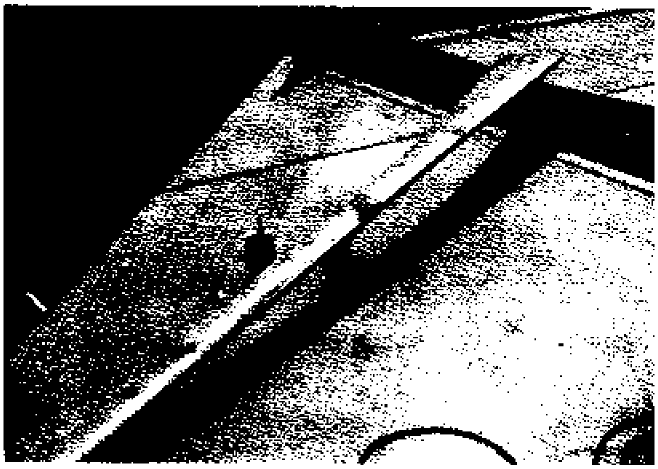


PHOTO 9.4

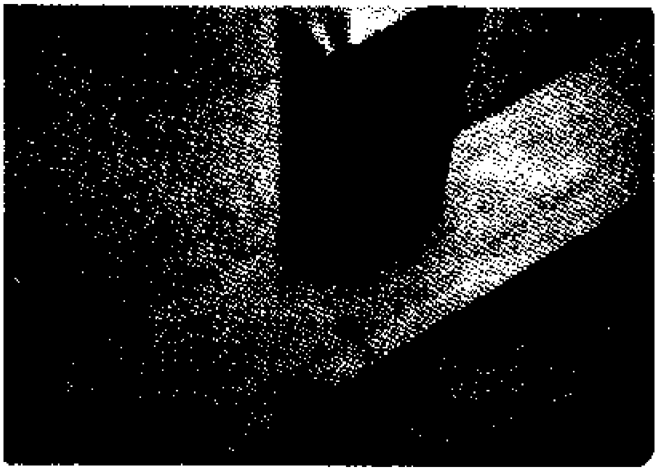
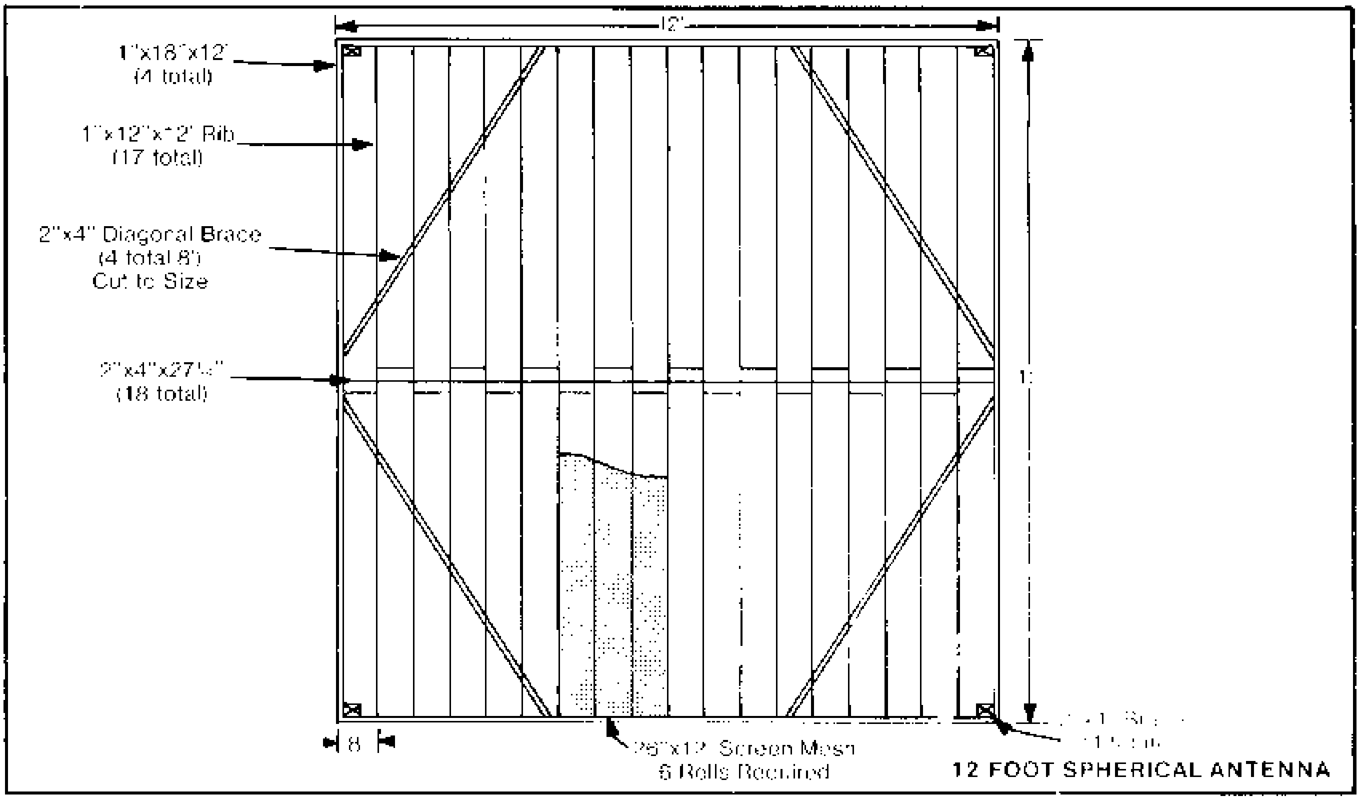


PHOTO 9.5

your first 7½ inch brace and nail and glue it to the left hand frame board flush with the bottom of the board as in photo 9.2. Find the first rib, determine which way it will face and then mark the side the side the nails are to go through. Start two nails as in photo 9.3. Prop the rib up on one end of the frame as in photo 9.4 and 9.4a; glue and nail it. Set this in its approximate position in the antenna but don't tack it in yet.

We will now do the last rib on the right. Find another 7½ inch brace and nail and glue it to a rib on the right side. The curve should be going away from the rib. If you refer to figure 9.1 you



12 FOOT SPHERICAL ANTENNA

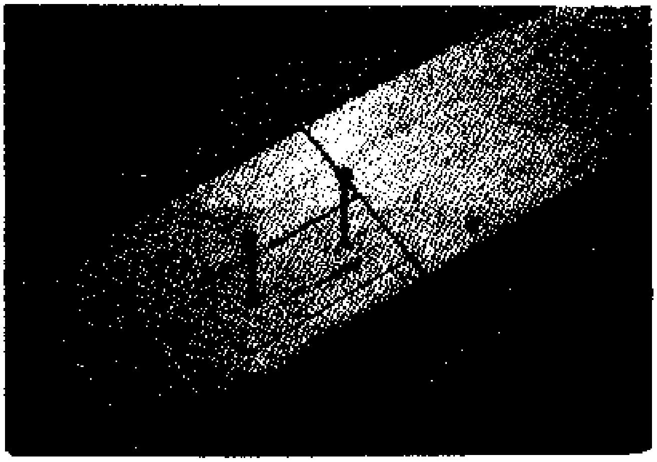


PHOTO 9.6

PHOTO 9.7

will be able to determine which side of the center line the brace will be installed. This time though, you will have to set the brace up from the bottom edge of the rib about ¾ of an inch, as in photo 9.5 and 9.6. This is because the curve is going the opposite direction. Take your time on this. I don't want you to have to tear a brace off the wrong side of the rib like I did. After adding the brace, set this rib in position on the right hand side of the antenna.

Now locate one of the ribs that was not cut on a slant. In the next section this rib will be tacked temporarily in the center position.

10.0) ADDING FIRST RIBS.

Take the rib without the 10 degree slant and place it in the center of the antenna frame as in photo 10.1. Take your best form and lay it across the center line of the antenna. Go to the top or bottom of the antenna and raise the center rib until it's curve is flush with the curve on your side then tack one nail in it to hold it in place. Go to the opposite side and do the same thing. It is easier to do this if you have a friend or spouse to help you. Get one person on each side of the rib and bring it up flush with the curve on each side while looking at how close the form is fitting in the center of the antenna. Now go look at the junction of the form and the rib. It should be within ¼ inch or better. Move the form back and forth across the curve to see how it fits. You should check

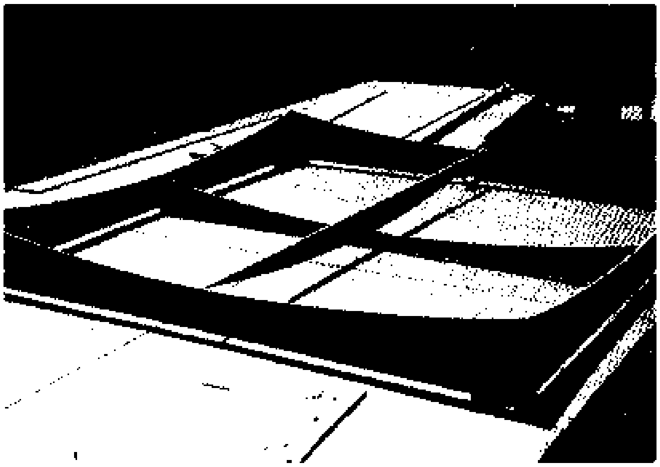


PHOTO 10.1

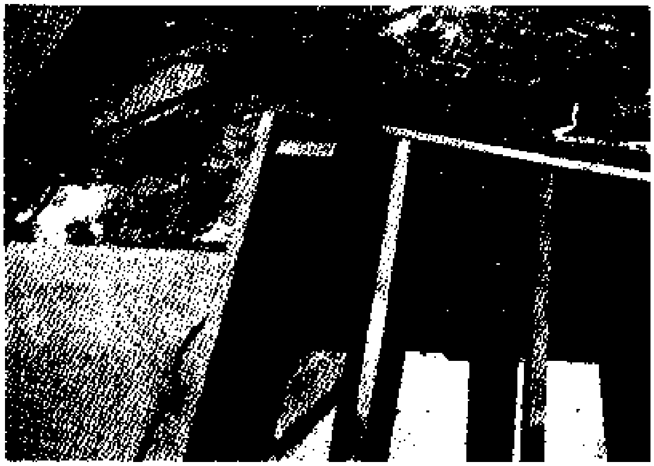


PHOTO 10.2

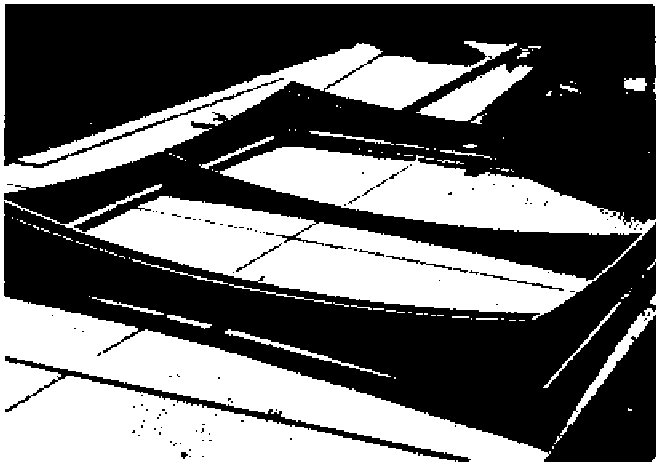


PHOTO 10.3

PHOTO 10.4

the fit every 2 feet across the antenna. If the form shows a large error, don't do anything yet. Let's first add the two ribs that were prepared in the last section.

Starting on the left, and using the same procedure as above, tack the rib in position. Tack the right hand rib in position at this time as well. The structure should look like photo 10.2. Now run the form across the curve and move all the ribs up and down for best fit. Don't worry if the rib has to set above the edge of the frame sides, these are only for reference. I did not have to move the first and last ribs, only the center rib. I stopped moving ribs when they all were within ⅛ of an inch of the form. Tack all the ribs in with 2 nails. You see why I had you draw a line down both sides of the frames to mark where the ribs go. You can use the lines to position your nails. Start a nail near the top and one near the bottom. Remember the rib does not necessarily go all the way to the bottom of the frame board.

With the 3 ribs holding the frame's top and bottom together remove the left and right hand frame sides. Be sure to mark the sides so you put them back in the right place. If the sides need to move up or down to better fit the curve now is the time to do it. Smear some glue all over the corner joints and nail them together. Do most of your nailing in the side that the 2x4 is located. We want to make the corners as strong as possible. Once again the structure should look like photo 10.2.

At one point I stated that if the rib was shorter than 12 feet we could still use it. I had this come up two or three times during the assembly of my antenna. In all of my cases, the rib was about ⅛ to ¼ of an inch too short. The procedure for saving the rib, as in photo 10.3 and 10.4, is to tack the rib in position and then nail a 2x4 to the wall of the frame. The rib is then nailed to the 2x4. If you use glue on the joints as I did the rib joint will be as strong or stronger than a rib without the 2x4.

11.0) INSTALLING DIAGONAL BRACES.

One of the problems with any square is that it is conditionally stable. That is, if left alone, it will hold its shape but any side forces will cause it to come down like a house of cards. To solve this problem, you are now going to install four 2x4's that will go from the center on both sides to a point between 5th and 6th ribs. Figure 11.1 will give you the exact dimensions. I suggest you put a 2x4 under each corner of the antenna so that the next procedure will be easier to complete.

The best way to install this rib is to take a 2x4 that is at least 7 feet long and slide it under the frame crossing under the edges at the points marked in the drawing. With the 2x4 poking out each side, run a pencil or felt tip pen along the inside of the frame to show where to cut the 2x4 off.

The purpose of this brace is to transfer some of the side loads

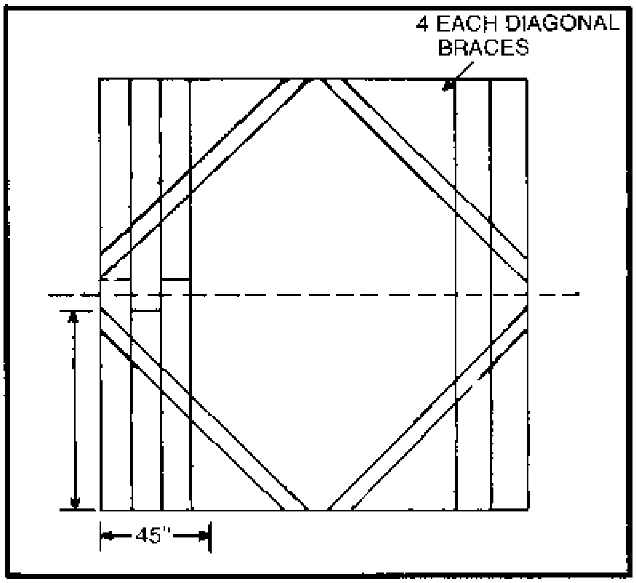


FIGURE 11.1

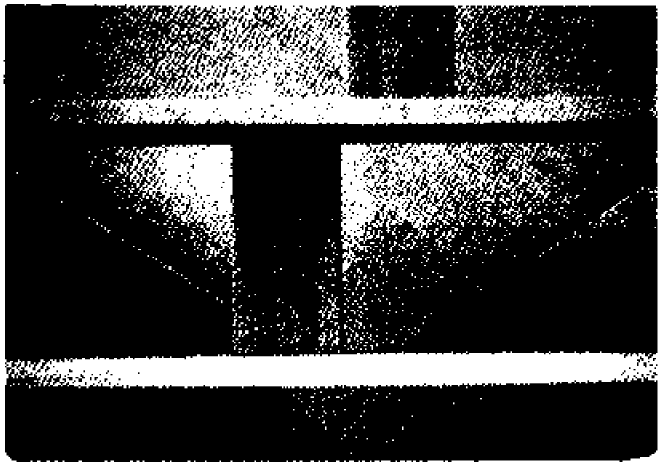


PHOTO 11.2

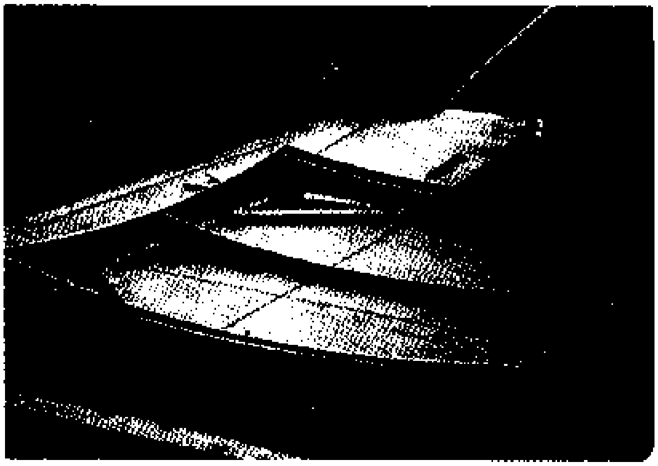


PHOTO 11.3

PHOTO 11.4

around the square. I elected not to have the brace go any further toward the center of the top and bottom frames than the spot between the 5th and 6th ribs. The further you go towards the center just means you will have to cut the bottoms out of more ribs, and in the case of the center rib you would cut so much out it could weaken the rib. You don't have to be too accurate as to the position of the brace. Don't go past half way on the side frame and any place between the 5th and 6th ribs will do.

All right, you have cut the 2x4 on the lines marked and are ready to install it. First point to mention is to be careful not to push the frame out of square as you nail the brace in place. If you do, the effect will be that some of the ribs will be too short or too long. You will swear that they were all the right length when you started but now they have expanded or shrunk. To do this job right you will need a patient helper.

The brace should be flush with the bottom of the frame and the diagonal cut on the 2x4 should be a good fit, as in photo 11.2. If it's not, then the glue won't hold. Start a nail in each of the frames on the outside of the brace, smear on the ever popular glue, hold the brace in position, and without distorting the frame, nail it home. Switch sides with your partner and nail that side in. Then go back and put a second nail in each brace. If your partner places their knee against the frame at the point the brace is attached, driving nails on the opposite end will be a lot easier.

Work your way around the frame installing the braces as above. You can tell if the antenna is no longer square, the center rib will either fall out or it will bow in the middle. You might ask how I know this. Don't, just trust me! That's a sure fire way to tell a parallelogram from a square.

I had to throw one brace away because of the sloppy sawing job I did on it. I also found that I had pushed one side out of square by about ⅛ of an inch. I elected to not do anything about it because I found that as I installed the rest of the ribs the frame would bend a little bit on each side and take up the slack. Your antenna should look like photo 11.3 at this point. In the next section you will add two (2) more ribs but then the third will hit the diagonal brace you just put in. I guess there's no such thing as free lunch.

Photo 11.4 shows the diagonal brace installed along with the ribs. You can see how the ribs were cut out to fit around the brace.

12.0) ADDING ADDITIONAL RIBS.

In previous sections we have covered the procedures required to install the ribs, so I won't repeat myself. Go ahead and add ribs from left to right till you run up against the diagonal braces, then stop and come back and read this section.

I cannot emphasize too much the care you should be taking when installing these ribs. They are defining the curve of your antenna. As stated before, the curve is all important, try to keep all deviations from your form to less than ⅛ of an inch. After we finish installing the last rib and are checking the curve, I will have a procedure for trying to bring some of the more wildly installed ribs back into conformity. I can assure you, installing them correctly the first time will be a heck of a lot easier than trying to repair them later.

Okay, I assume you put your diagonal braces in the same place I did. That means when you try to install the fourth rib it hits the brace. (Photo 12.1) If the rib can set in its position without falling over then you won't need any help with this section; if not, then bring out the assistant. (the long suffering spouse; I would say wife, but that would be sexist.)

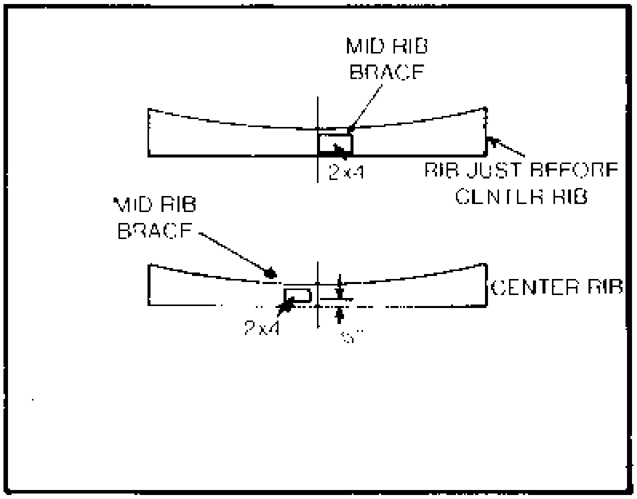


FIGURE 12.8

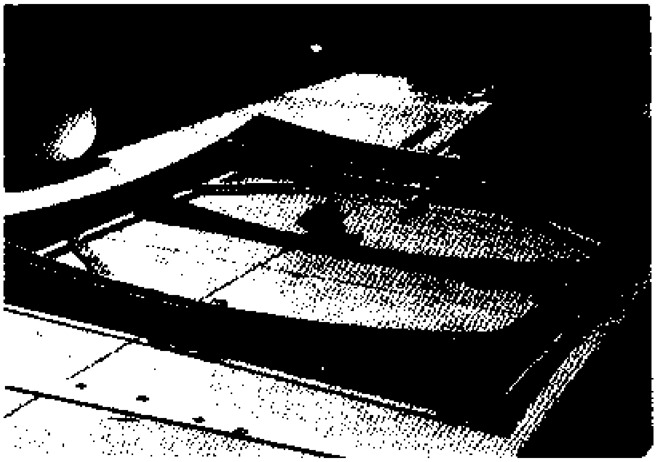


PHOTO 12.1

Put the rib in its exact position, so that it is sitting on the brace as in photo 12.2. Get the felt tip pen and mark on the rib the spot where it lays on the brace. Be careful to mark the spot where the cut will begin on one side of the rib and where it will end on the opposite side of the rib. (photo 12.3) The brace passes under the rib on an angle so the cut-out has to start where the brace first crosses the rib and end where the brace comes out the other side. This seems like a simple thing, but I had to lengthen the cut-out on a couple of ribs so I must not have been paying attention to what I was doing. To this point, I would suggest adding [illegible] of an inch to each side of the cut-out so you won't have to go back and do it again. Be sure to note how much the rib sits above the frame. This tells you how deep to make the cut out. As before I would suggest adding [illegible] to [illegible] of an inch to this depth for insurance.

You have marked both ends of the rib and are ready to make the incision. Well doctor, I suggest using the Saber saw rather than a scaple, it's faster. Set the Saber saw for a flat cut and make the first cuts to define the cut-out area. To make the long cut, just start on an angle and slowly match the line. Then turn around and go back to make the cut-out square like photo 12.4. This photo also shows why you make the short cuts first, the end of the rib developed a crack and broke off. That's why one side of the photo shows a shorter cut-out. I found that it was easier to just cut all the way to the end of the rib. If the amount of wood that is left is too weak to do any good, as in photo 12.5.

PHOTO 12.2

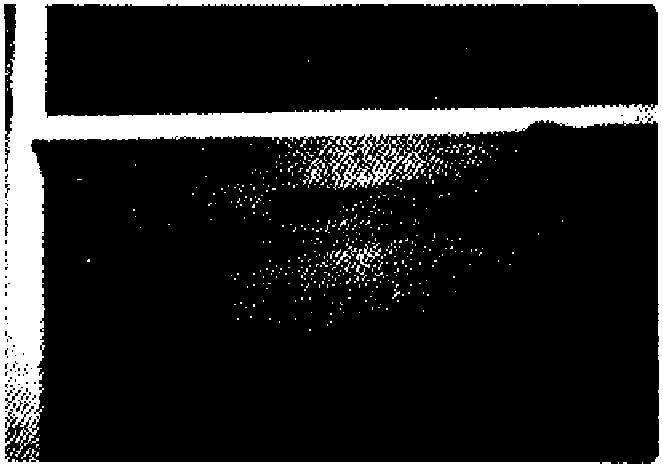


PHOTO 12.3

Last step, take the newly customized rib and set it in place. If it fits in all respects, set the curve as mentioned before and nail it in place. (Photo 12.6) If you put your diagonal braces in the same

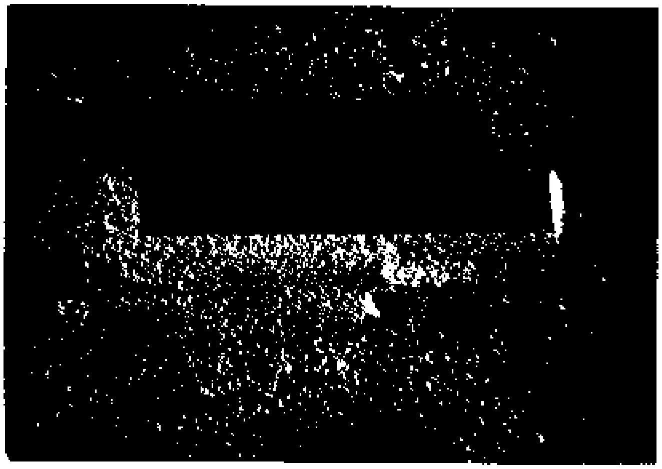


PHOTO 12.4

PHOTO 12.5

places I did, you will have to custom fit only two (2) ribs on each end of the antenna for this brace cut-out. (Photo 12.7)

There should be smooth sailing from here on until you get to the spot on the other side where you will have to customize the ribs to fit over the diagonal braces. Go ahead and put in the rest of the ribs. Remember, when you get to the half-way point you will have to change the way you install the midrib brace. In case you have forgotten or didn't read that part in section 9.0, I will go over it again.

As you build this antenna from left to right, the ribs are slowly setting lower in the frame. Putting the midrib brace flush with the bottom is okay because the next rib will be lower than the rib you're putting in now. Because of that fact, you will have to set the midrib brace ¼ of an inch up from the bottom of the rib. Figure 12.8 shows this a little better than the pictures.

Photo 12.9 shows the antenna half done with the form in place for checking the curve. All I did when I checked the curve was to check it at a point 2 feet in from each end and the middle. If you did a good job on cutting out the ribs, the rest of the curve will be okay. I found that somehow the left side frame board was mounted ¼ of an inch too high, which made all the ribs look like they were too low in the frame. Photo 12.10 shows the fit when I laid the form so it missed the frame on the left. The curve is within 1/16th of an inch all the way across the antenna to the half way point. In a latter section, I will cover how to fix that high point in the curve. As I put in the ribs, I noticed that even though the form said the rib was in the correct position, when the rib got to the edge at the frame, some of them set up above the frame by ¼ of an inch (Photo 12.11). I assumed this was due to the Saber saw making a mistake. Sounds good to me!

PHOTO 12.6

Go ahead and install the rest of the ribs. When you get to the diagonal brace on the other side, just use the previously mentioned procedure to modify the ribs. The next and last problem area is installing the last rib and midbrace. When you get to that point, come back and read how I solved that problem.

The problem is that we had to install the right hand frame and

PHOTO 12.7

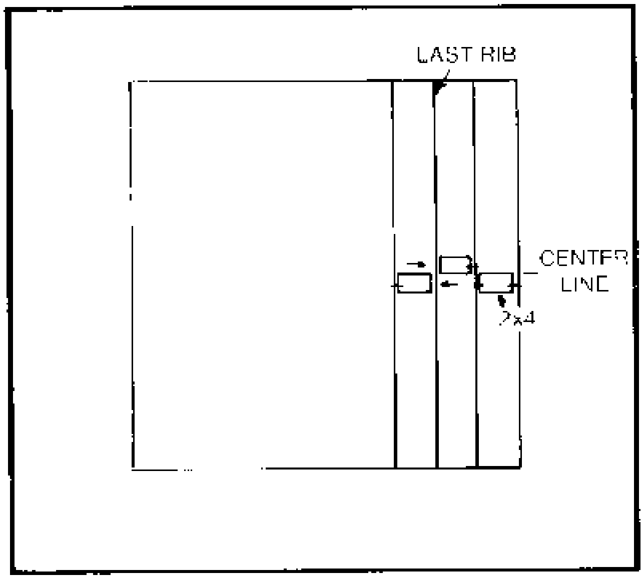


FIGURE 12.12

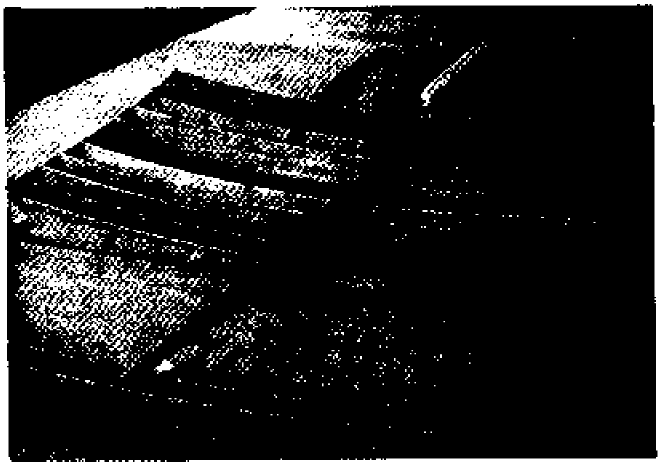


PHOTO 12.9

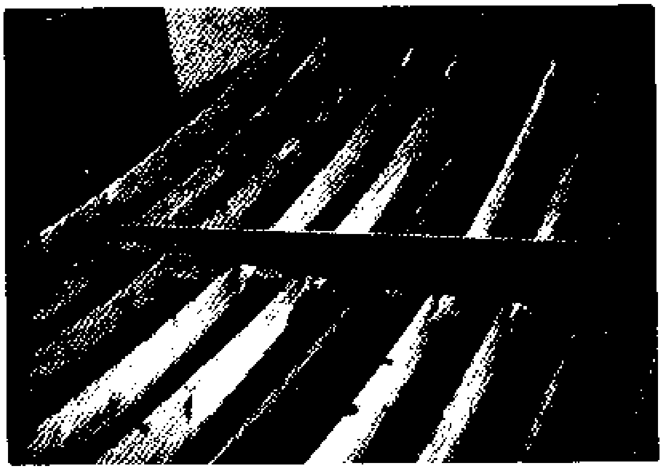


PHOTO 12.10

PHOTO 12.11

PHOTO 12.13

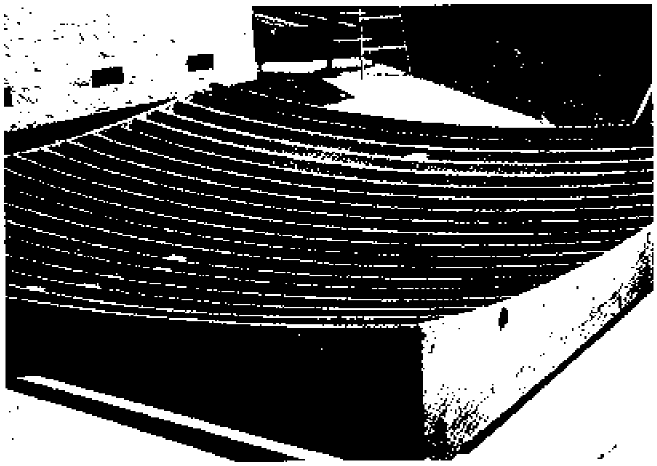


PHOTO 12.14

the last rib at the very beginning of this assembly procedure. The last rib then is really the second from the right rib (Figure 12.12). If you have kept track of the positions of the small midboard brace then there won't be a problem where to put the last brace. If you have gotten out of sync and the last brace wants to go where there already is one, like I did, then let me diverge a moment to solve that problem. All the rest of you who got it right can skip on ahead.

If you have two midboard braces occurring on the same side of the centerline, you will have a devil of a time nailing the last one in. To solve that problem, I moved the last brace up as close to

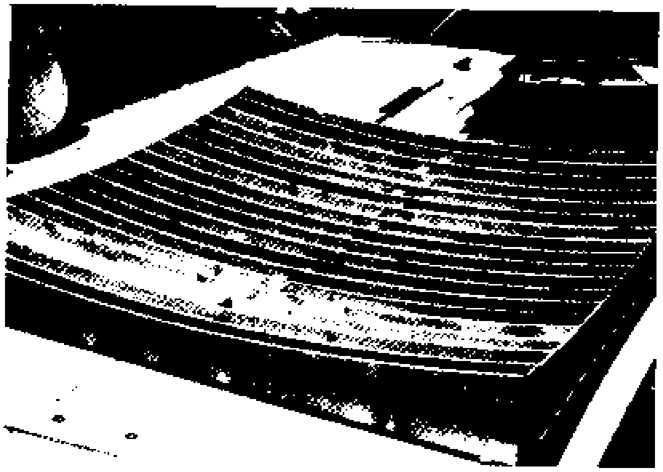


PHOTO 12.15

the curved surface as possible. That let me get close enough with a hammer to be able to drive a nail or two into it.

For the rest of you who kept the sequence of the midboard brace correctly here is your procedure for putting in the last rib and brace. You have two ways of skinning this mountain lion; you can raise the whole structure up far enough to slide under it and nail the brace from that side or install the last brace as high as possible towards the curve and nail it from on top. When I got to this point not only was I out of sync with the center line but the normal 7¼ wide brace was too big by ¼ inch. I set the rib in place with a couple of nails and then made multiple trips to the saw till the brace fit. Yes, I did measure it the first time but that didn't work either. I told you this was my first real wood working project since high school. Once the brace was the right length and I had decided how I was going to nail it in place I pulled the rib, nailed on the brace and installed the last rib!!!

If you don't want to bother nailing this last brace, go ahead and just smear it with glue and let the pressure from the rest of the antenna hold it in place till the glue dries. I don't think it will fall out.

Well, photo 12.13 shows a definite lack of wood laying about on the floor of my garage so that must mean the hard part of assembling the antenna is over. Your antenna should look very much like photos 12.14 and 12.15; if not, what are you building?

13.0) ALL RIBS IN PLACE, FINAL FIT.

This is the point in the construction where you try to bring into line any of the errant ribs. Before you do anything about the curve or lack thereof, run the form from one side to the other at one (1) foot intervals and on a piece of paper and note which ribs are out of tolerance. How close you try to hold the curve is really up to you. The closer the better. I tried to hold all ribs to ⅛ of an inch and succeeded. The most you should let it slide is ¼ of an inch. You should have no trouble holding this tolerance if you took your time in the cutting and assembly of the ribs. (Photo 13.1)

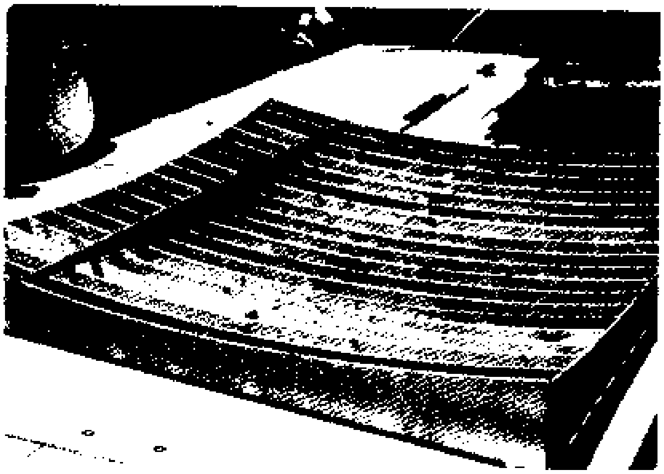


PHOTO 13.1

What you will find after running the form over the antenna and making some notes is that there will be one or two ribs that are out of alignment. If they are on the high side of the curve, then the following procedure will solve that problem. If, on the other hand, the errant ribs are on the low side, you can't lower the surrounding ribs because that will throw the curve too far off. If you find one rib really low on the curve, you could try pulling out the nails on the ends and saw through the braces. Then reposition the rib to better fit the curve.

I found that I had two ribs that were out of the curve by ¼ of an inch. So what you do find your hand plane, set it for the smallest bite it can take and slowly, and I mean slowly, work the curve of that one rib down to the rest of the ribs. You can see the danger in this, if you get over zealous you could make it worse and force the removal of that rib.

You may find that the rib will have only a certain area out of tolerance. That is the easiest problem to fix. You can still ruin it, but you don't have to remove so much wood to get the rib to match the curve. If you do have to lower one or two ribs, as I did start at one end and go all the way across the rib, taking two or three swipes at the rib with your hand plane. Then stop and put the form along the rib parallel to it, to check its curve. Then put it across the antenna to check total conformity. Work your way back and forth a little at a time being very careful. Depending on the amount of wood you have to remove, this process could take a couple of hours. In my case for two ribs, I took about an hour each to get them where I wanted them. Be sensitive to the fact that we want a slant on each of the ribs except the middle. So as you plane the wood off be sure to keep the slant going the right direction and the right angle. You can check this each time you

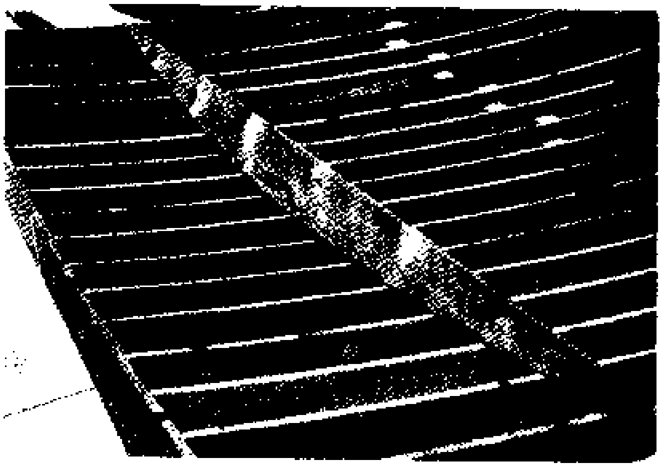


PHOTO 13.2

PHOTO 13.3

lay the form across the rib.

Good, bad, or indifferent, the ribs are where you like them. When you lay the form across the antenna, all the ribs should be within [illegible] of an inch worst case, as in photo 13.2. The form in this picture is leaning to the side. That's why there appears to be a gap under all of the ribs. When the form is standing up straight, the gaps were within [illegible] of an inch of the bottom of the form. Good enough for government work!

If you look under the antenna, you will notice that some of the ribs stick out below the frame at the center of the top and bottom frames. In my case, since I used an 18 inch wide frame, only the center rib and the three (3) ribs to each side were sticking out. If you used smaller boards for your frame, then more ribs will be sticking out. We will have to cut all these off flush with the frame to keep them from hanging up when we raise the antenna. Also, since the antenna will always be leaned back, the weight concentrated on these ribs could distort the ribs as it fits into the curve.

First step is to raise that side of the antenna you call the bottom. To do this I grabbed two bar stools from the house and propped the end of the antenna up on them, one under each corner. This will be the first time you have tried to lift your antenna, so be careful! The job takes two people, one at each end. Both of you lift at the same time, trying not to twist the frame. Slide the stools, or what-ever, under the corners of the antenna. Take a straight edge and scurry under the structure. Place the straight edge against the frame, hold the straight edge level and draw a line from the frame till you run out of ribs. In the case of the center, which sticks out from underneath the frame the farthest, the length of the cut was about [illegible] inches. Do this to all the ribs that stick out, then go get your Sabre saw. Start your cut in the rib and work your way out to the frame. At some point, the blade guard of the saw will run into the frame and you won't be able to cut any further. That's okay, just grab the piece of wood you are cutting out and pull on it. It should break off. Do this to all the ribs. When you're finished, the underside of the bottom frame should look like photo 13.3.

Put the antenna back down on the 2x4's and you are finished with the assembly of the frame. The next step is to cover the antenna with the reflective surface.

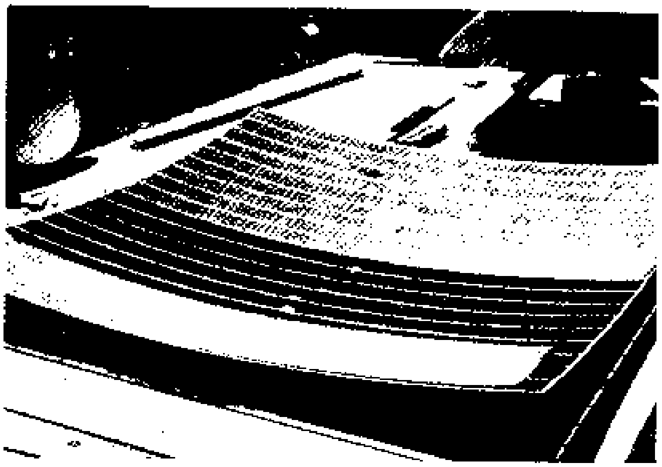


PHOTO 14.1

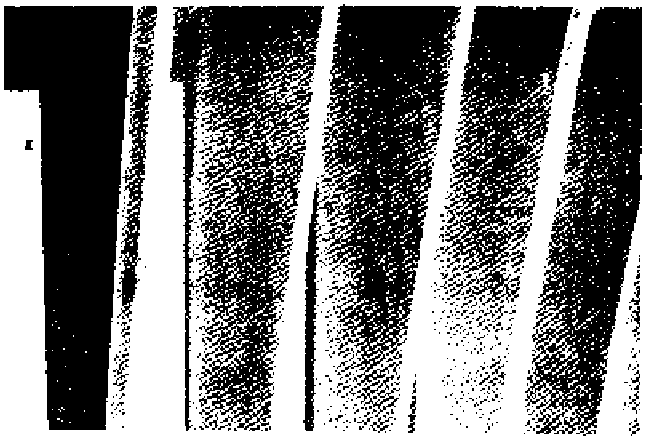


PHOTO 14.2

14.0) ATTACHING THE REFLECTIVE SURFACE.

With this next step you will turn this collection of wood into a real live antenna, ready to do yeoman service for a good many years. Your first problem is to decide how large a mesh opening is right for your area. If you live where you will get a lot of snow, hail or big winds, a good deal of the time, then I recommend covering the surface with the mesh that has ½ inch openings. This is to reduce wind loading and better withstand snow and hail. The other size is the so called window screen size mesh. I used the smaller size mesh to cover my antenna. The smaller the mesh you use will make the next section easier.

Having decided on the mesh size, go buy 6 rolls 26-inches wide by 12 feet 6 inches long. Armed with the mesh and the staple gun, you are ready to begin. I discovered, the hard way, that you should pick the hottest part of the day to put the screen on the antenna. I installed the first run of mesh in the late evening and the next day, as it got hot outside, the screen I had put on the night before started to expand and got all pushed out of shape. I waited til I was sure the temperature was as hot as it was going to get, then I pulled out all the staples and stretched the screen to smooth out the wrinkles. Then at night the screen shrinks and the surface only gets tighter, and that's good. With that in mind, I laid the next roll out across the antenna and let it get nice and warm. Photo 14.1 shows my antenna with two (2) sections stapled down and the next section about to be stapled. The screen that is laying across the antenna at the end is heating up so it can be used next.

The mesh I used was 26 inches wide. This is wide enough to cover four (4) ribs at a time. The screen mesh is available in wider pieces but I found that wider material did not want to lay as flat as the 26" material. Since the ribs are 8 inches apart, there will be a over hang of 1 inch on each side. (Photo 14.2) To do this job properly will require two people. Try not to bend or distort the mesh as you work with it, you will never get it smoothed back out. With one person on each side, work the mesh back and forth and pull it straight between you and your partner till it is straight with no ripples or bumps in it. I found that the mesh would take a natural lay, and if I could use it in this position, it would be perfectly smooth across the curve. Once the overlap is correct and the mesh is laying smooth, place a 2x4 across your end and go around to the other side and put in 3 staples along the frame, not in the ribs yet. Go find yourself a flat stick ½ inch wide and 3 inches long. You will use this as a guide to the staple spacing and to keep the mesh flat as you staple along the ribs.

Photo 14.3 shows how I worked my way across half the antenna, putting staples in the rib, where the screen material overlaps, every three inches. You can put the staples closer together if you like. The closer they are to each other, the tighter the surface will be stretched over the ribs. I chose 3 inches as a compromise: as it was, I put in over 2,000 staples.

When I got half way across the antenna, I went back and started over again, except this time I put staples in the other ribs. There are two ways you can get the screen material to stretch across the ribs. In both cases you have to always pull the material straight across from a staple. If you pull diagonally across from a staple, you will cause a ripple to occur between staples. The first method is the one I used. Photos 14.4, 14.5 and 14.6 show this method. While putting a slight tension on the material, I stapled each rib working toward my hand. The second method is to staple the rib by your hand then go back and catch the other ribs in between. I tried both methods and could not see any differ-

PHOTO 14.3

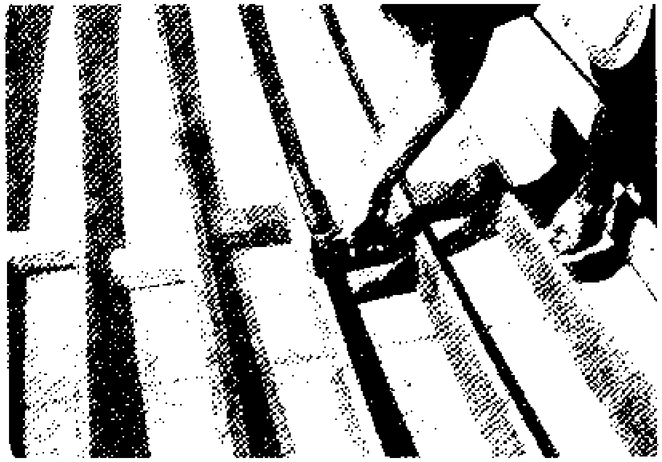


PHOTO 14.4

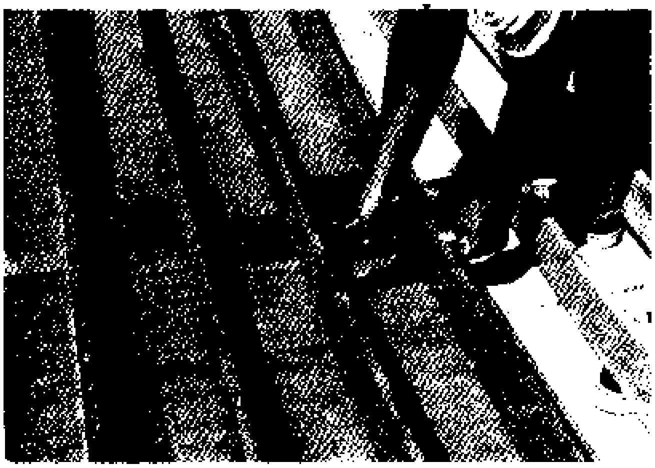


PHOTO 14.5

PHOTO 14.6

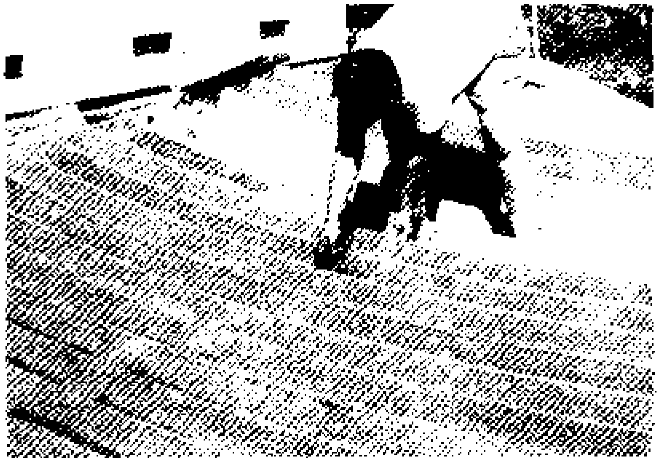


PHOTO 14.7

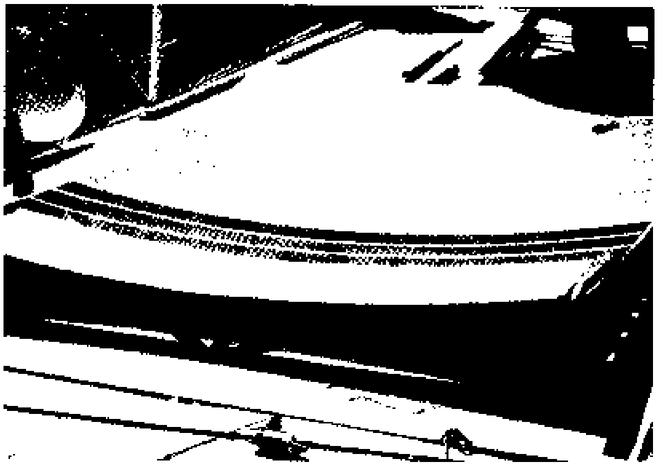


PHOTO 14.8

PHOTO 14.9

ence in the finished product.

When you have worked your way to the middle of the ribs with the screen stapled down, do the rest of the run, starting over with the 3 inch stick, Photo 14.7. The reason for doing half the run at a time is to minimize the chance of putting the screen on with ripples in it. Photo 14.8 shows another run of screen material stapled down, two more to go. Always work across the antenna in the same direction. Never start at both ends and work towards the center of the antenna.

At last, photo 14.9 shows a completed antenna, ready to be put on the air. If you look closely on the far side of the antenna, you will see the first run of screen looks different. This is because the material was put on the night before and as the sun heated the material it expanded. As you can see it is buckling quite a bit. I had to go back and pull all the staples out of that run and re-stretch the screen.

15.0) ANTENNA STAND.

Building the antenna stand can be the most frustrating part of the construction project. You have a perfectly good antenna laying on its back ready to go, and now you build the mount. When I was at this point, I was tempted to lean the antenna up against the house. I thought better of it when I considered having to rebuild the whole structure after it fell, for lack of a good mount. GAD!!!

This section will cover two mounts, a ten foot mount and a twelve foot mount. I believe either mount will work anywhere in the U.S., as far as the look angle is concerned. If you are trying to get a look at a satellite that is low on the horizon, like 10 degrees or less, the antenna will be almost vertical and will have to be secured to keep it from falling forward. In a case like that, I would suggest a mount that is longer than 12 feet. That way, the mount will extend behind the antenna and form a triangle. The mount can then be secured to the ground and hold the antenna in position with this low look angle.

For the rest of us with a more reasonable look angle, as in my case 45 degrees, we have to decide which mount will do the job. The strongest mount is the 12 foot one, but it also takes up the most room. I built the 12 foot stand first, stood the antenna up, then noticed how much room it took (Photo 15.1). I could not find the focal point as it was in the neighbors yard by two feet. That's when I got the great idea to build a mount that took up less room. (Photo 15.2)

Refer to drawings 15.3 or 15.4 for all dimensions of both the 10 foot and 12 foot stand, the only difference being the length of the vertical 2x4's. The only critical dimension is the overall width of the stand. The idea is that the stand fit inside the frame of the antenna as can be seen in photo 15.5. So the dimension given in figures 15.3 and 15.4 assumes the inside dimensions of your antenna are the same as mine. To be on the safe side, I suggest you measure the inside dimension of your antenna and use that number for the outside dimension of your frame. You will have to

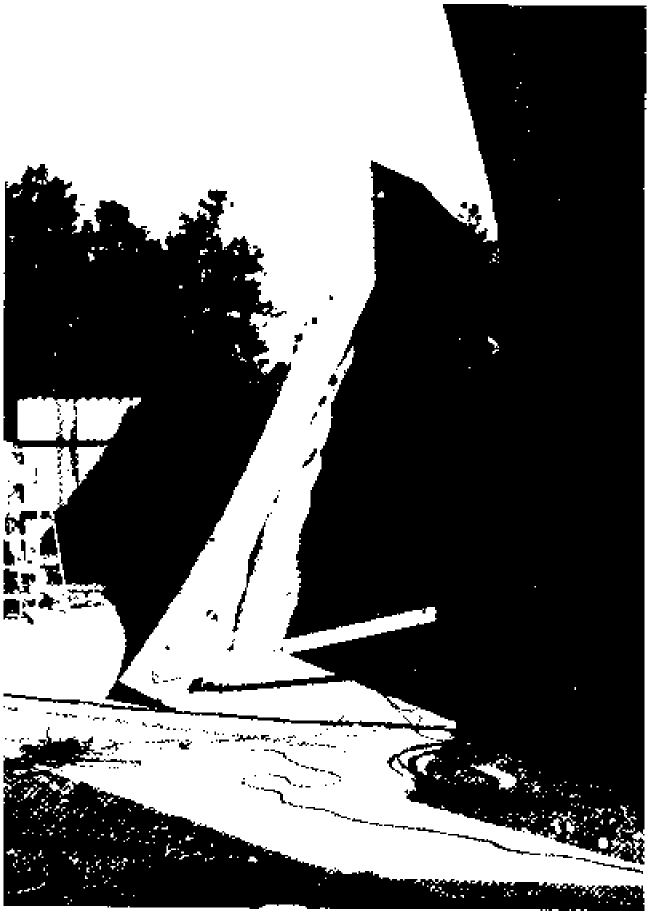


PHOTO 15.1

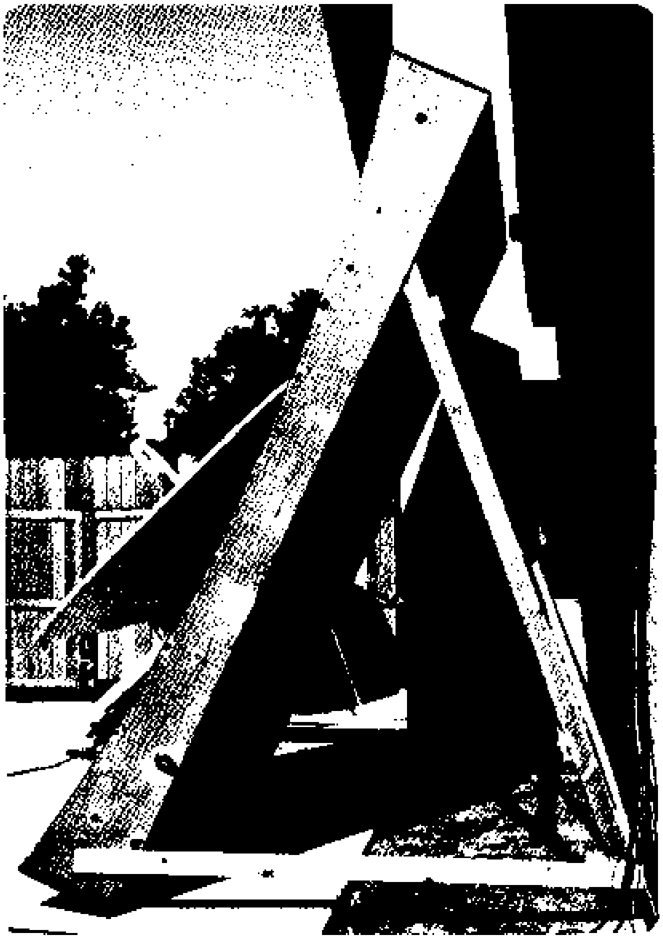


PHOTO 15.2

cut the two 2x4's that make up the bottom and center cross members so that the outside dimensions of the stand will fit in the frame. Just a reminder, a 2x4 isn't really 2 inches by 4 inches. It is 1½ inches by 3½ inches. The reason I bring this up is to help you compute the amount to cut off the 2 cross members. It will also be necessary to insure that the 2 vertical 2x4's are the same length. Their actual length is not critical, as long as they are the same. The reason for this is to insure that the antenna will not be twisted when set on the frame.

This job will require your trusty assistant. Lay all the boards out in their proper position. Start two (2) #10 nails on each end of the vertical 2x4's, smear on the glue and nail them together. I found that if the assistant places their foot against the end of the 2x4 being nailed, the job will be easier. After nailing two boards together that are supposed to form a right angle, get the corner square out and place it in the junction of the 2x4's. Adjust the position of the boards till the frame is true. Do this on all the corners as you nail them together. The next step is to install the cross braces. You are given a choice on how you install the braces based on the length of the 2x4's you bought. The one piece braces require a 2x4 length of at least 16 feet long. The multiple pieces brace require four 2x4's 7 feet long. Photo 15.6 shows the 12 foot stand with one piece braces, all finished and ready to be attached to the antenna. You will note that in the case of the one piece cross brace, one brace is on one side of the stand and the other brace is on the opposite side of the stand. It will be necessary to turn the stand over to attach the other brace. Be very careful with the stand at this point as it is not very strong, the glue isn't dry and you could twist the stand as you turn it over.

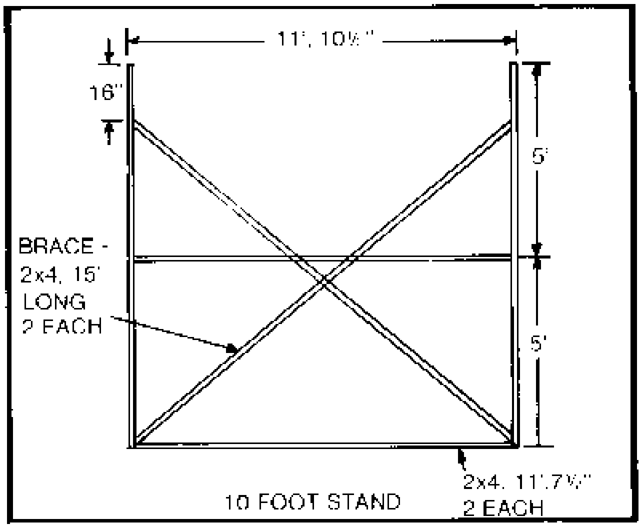


FIGURE 15.3

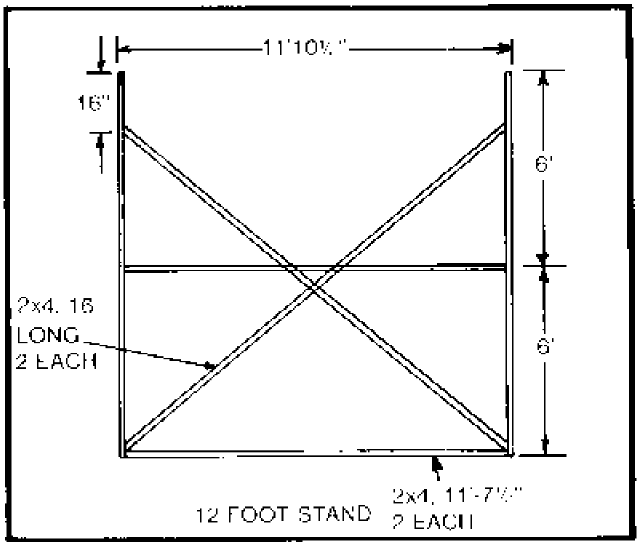


FIGURE 15.4

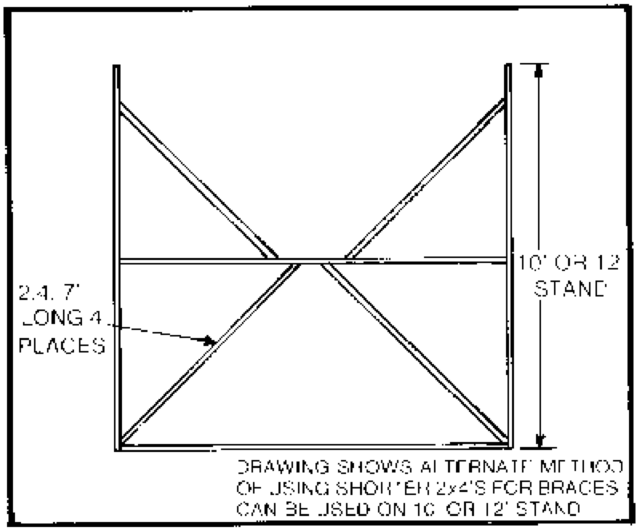

10' OR 12' STAND
2x4, 7' LONG 4 PLACES
DRAWING SHOWS ALTERNATE METHOD OF USING SHORTER 2x4'S FOR BRACES CAN BE USED ON 10' OR 12' STAND

FIGURE 15.6

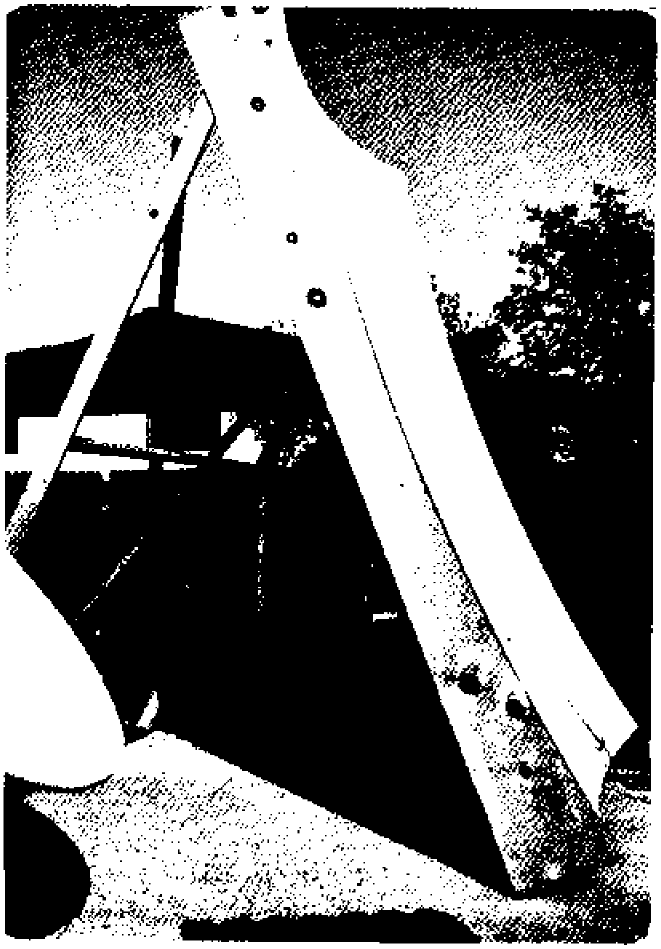


PHOTO 15.5

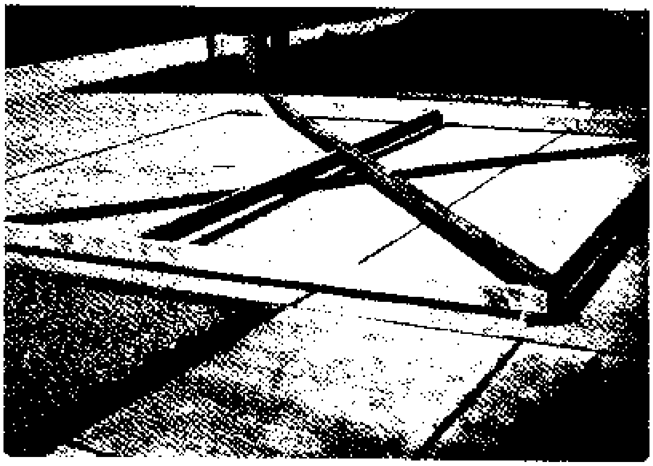


PHOTO 15.7

Whether you use the one piece brace or multiple piece, they don't extend all the way to the top of the vertical boards but stop 16 inches below the top of the board. This is to allow the stand to extend into the antenna frame. Finish assembling your stand then go find the drill and ⅝ drill bit or wood auger. At a point 2 inches from the top of the vertical board drill a ⅝ hole in the center of both 2x4's. This is where the stand will attach to the antenna frame. Let the stand rest for a couple of hours so the glue can dry.

You will have to drill a mating hole in the antenna frame for the stand to bolt to. If you built the 12 foot stand then measure down from the top of the antenna 12 inches and 7 inches in from the back and drill a ⅝ hole in the frame, one on each side. If the 10 foot was right for you then measure down from the 24 inches and 7 inches in from the back and drill a ⅝ inch hole. Try to be as accurate as possible with these measurements so the antenna will set level on the stand. I think that does it.

Time to raise the antenna.

16.0) STANDING THE ANTENNA UP.

In this section we will attach the stand to the antenna, hopefully in its final operating position. You will need at least five people to help you raise the antenna. I suggest you throw a barbeque for five friends and when they show up, plead for their help. I raised my antenna with just four people, but they were all dedicated satellite types. As my crew and I raised my antenna it became obvious we needed another set of hands. Learn from my mistakes, get the fifth person.

I will assume that you have determined your look angle to the satellite and know which way to point this thing. If not, I would suggest you go back to section 3 and determine the look angle at this time. You should have all the nuts, bolts and washers in your pocket with the correct wrenches close at hand. If you are lucky enough to have lots of room for this antenna and frame laying end to end this job will be very easy. I will deal with this case first.

Have two people, one on each end, evenly lift the antenna up far enough to slide the frame up inside. Attach the stand to the frame using the ⅝ inch hardware. Be sure to put a fender washer on both sides of the hardware. This is to keep the wood from compressing as you tighten the nuts down. With the stand attached, walk the antenna up to a stable standing position. This is done with a person on each side of the stand and the antenna, all lifting together. Try not to twist the antenna as you do this as that could stretch the screen mesh surface and cause bubbles to occur.

PHOTO 16.1

If you have limited space, here is your procedure. You will need a 6 foot step ladder to install your stand. Get the two strongest people on the antenna. The other two people will hold the stand vertical right behind the antenna. Raise the antenna up until you can slip the stand under the lip of the frame and rest the antenna on the stand. This will take the pressure off the people holding the antenna. Grab your ladder and get up to the point where the

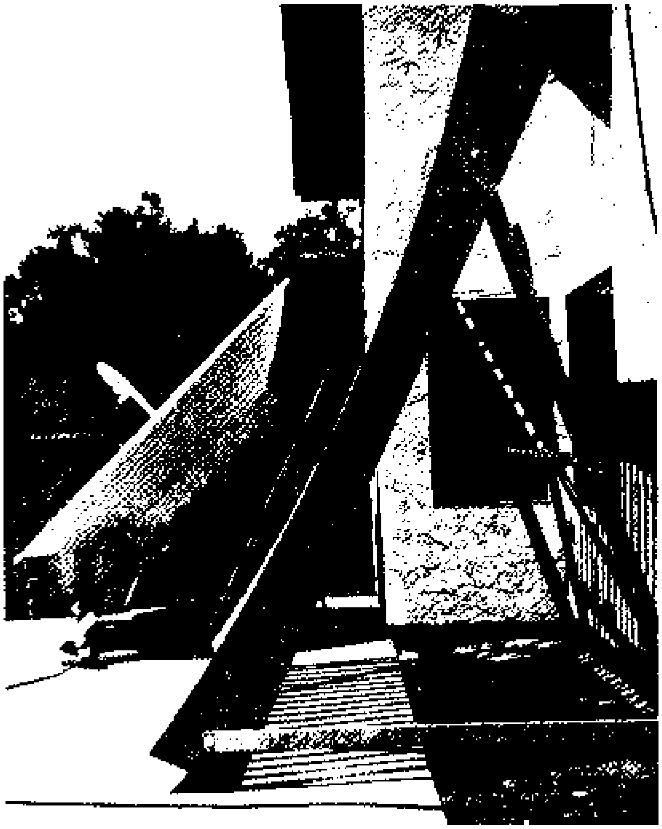


PHOTO 16.2

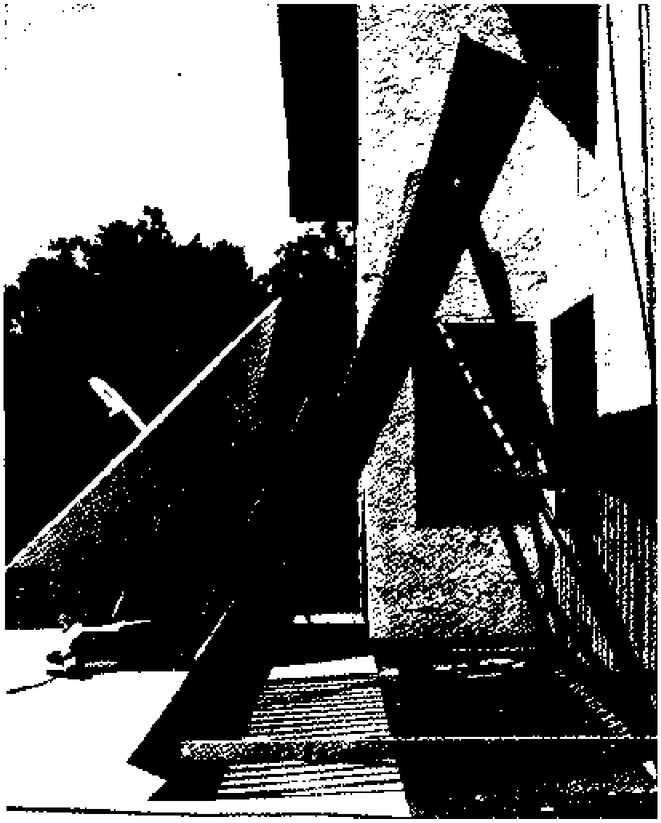


PHOTO 16.3

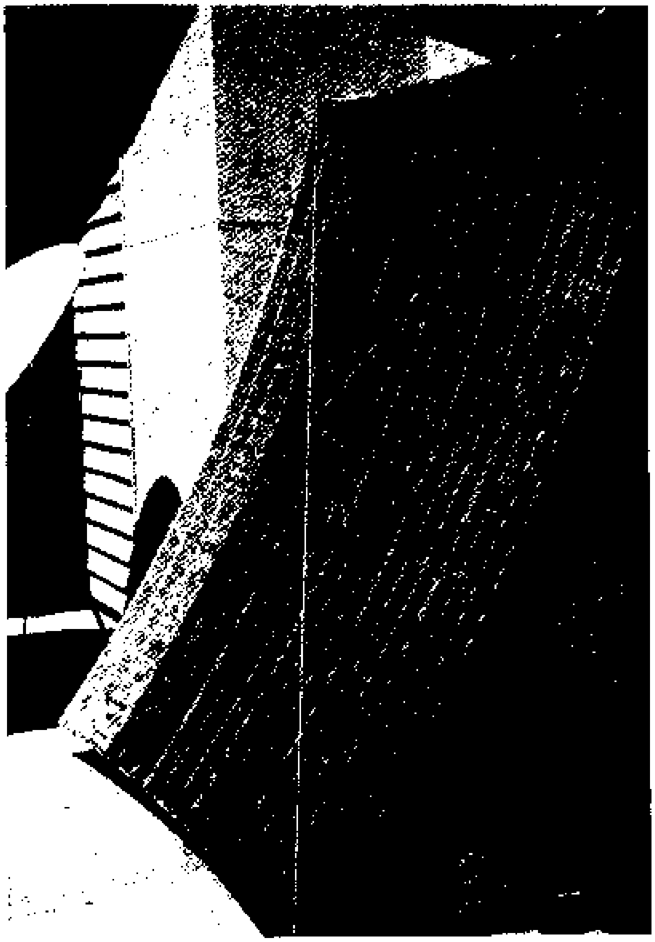


PHOTO 16.4

bolt holes are. You then lift your corner of the antenna off the stand on your side and slide the stand down to line up with the bolt hole. Bolt them together, run around to the other side and do the same thing. The big risk is that the stand will get away from you as you do this and punch a hole in the screen mesh. Be careful!!!

With the antenna level, set the elevation of the antenna with the inclinometer and attach the two side braces as in photo 16.1. If you don't or can't buy an inclinometer, you can make one by following the instructions in section 3. The braces will keep the stand from slipping out from under the antenna. Keep the 2x4's you use for this as long as possible so you can change antenna elevation if you go looking for other satellites. In my case, I had to cut them off right at the stand so I could push the structure as close to my house as possible. The braces are held on with more ⅜ inch hardware. The position of the braces are up to you, just make sure you don't twist the antenna as you attach the braces.

When the antenna is in its final position the antenna frame should be level across the width of the antenna and should not be twisted. Step back from the side of your antenna and sight across the edge lining up the far edge and the close edge. You should see the same amount of the antenna sticking out the top and bottom of the frame, as in photo 16.2. If the antenna is twisted, you will see more of the top or bottom as in photo 16.3. I put a 2x4 under the far corner in that last photo to get the far upper corner to stick out more than the bottom. The reason for all the concern about this twisting is to keep all the antenna reflective surface focusing at the same point. If one section is twisted it will focus some place else and we will loose the usefulness of that section of antenna.

One way to make sure the antenna is sitting flat and not twisted is to staple a string from corner to corner as in photo 16.4. The strings will have to be pulled very tight to remove all the slack. If the antenna is not twisted the strings should just barely touch as in photo 16.5. If the strings miss or pushing on each other, then you should check to see if the antenna is really as flat as you think it is. Make sure the strings start in the same place in each corner of the antenna.

PHOTO 16.5

17.0) CONSTRUCTION OF FEEDHORN AND SUPPORT STRUCTURE.

In the following section, I will cover how to build a feedhorn, mounting brackets for the feedhorn, and pole mount and the support structure. If you do not want to build all this, a complete system is available from Vidiark Electronics Development Co., P. O. Box 57, Salem, Arkansas. Phone: (501) 895-3167. They will ship you a tripod with rotor, feedhorn and brackets for about $200.00. If you order this equipment before you start the antenna, it will arrive before you finish. I will assume that if you build the antenna you will want to build the rest of the equipment as well.

The first item to be built willl be the feedhorn. The purpose of the feedhorn is to collect the energy that has been focused at a certain point by the antenna. I should point out before the mail start coming that a spherical antenna does not have a focal point, it has a focal line. So the correct feedhorn should be a line feed. However, those are extremely hard to build and the feeds we use are close enough. So from now on I will talk about the focal point, and you engineers will have to grit your teeth.

Photo 17.1 shows the four different feedhorns I tried on my antenna. The first one on the left is homemade out of P.C. board material. The second one was bought from Vidiark Electric mentioned above. The third one came from Tristar Corporation. As far as I can tell, they are no longer in business. The last feedhorn came from Chaparral Communications, 103 Bonaventura Dr., San Jose, CA 95134. Phone (408) 262-2536.

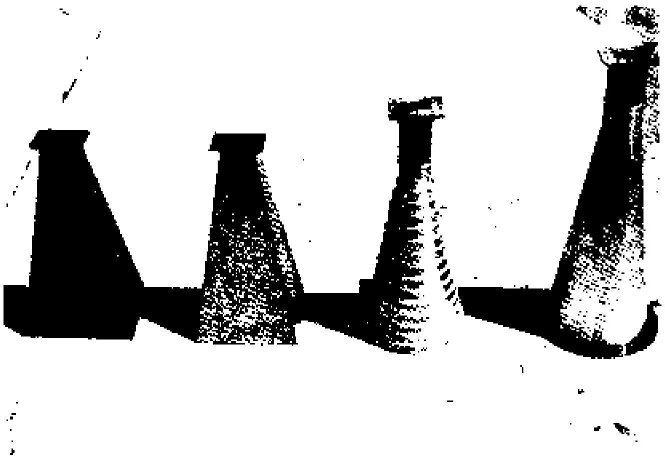
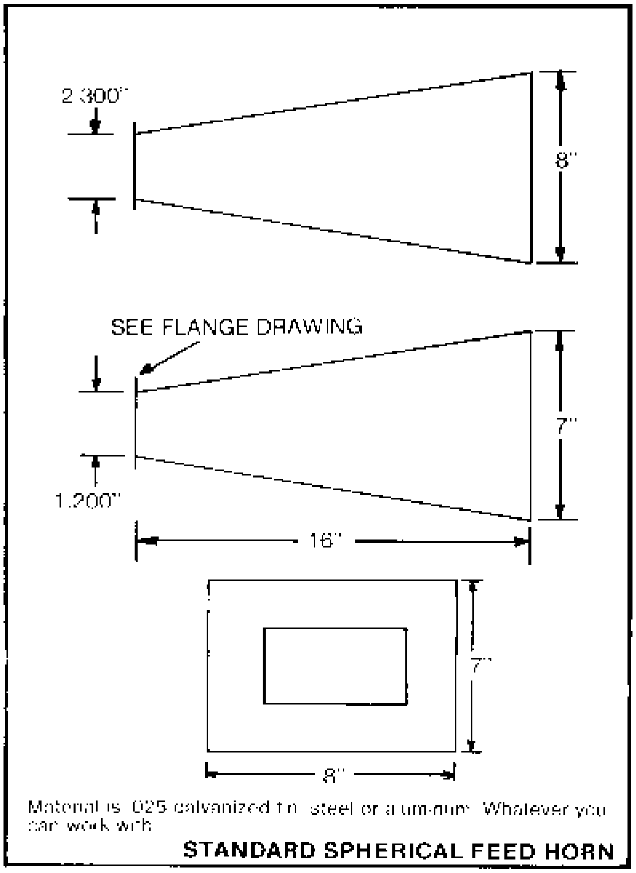


PHOTO 17.1

I could not tell the difference between the first two feedhorns even though I have read that P.C. board material makes a poor feedhorn. The Tristar horn worked about .5 dB better than the first two horns. The last feedhorn, the Chaparral, worked about 1.0 to 1.5 dB better than the first two feedhorns. All performance data listed in section 19.0 was done with the homemade feedhorn. So if that performance is not to your liking you can



Material is .025 galvanized tin, steel or aluminum. Whatever you can work with.

STANDARD SPHERICAL FEED HORN

FIGURE 17.2

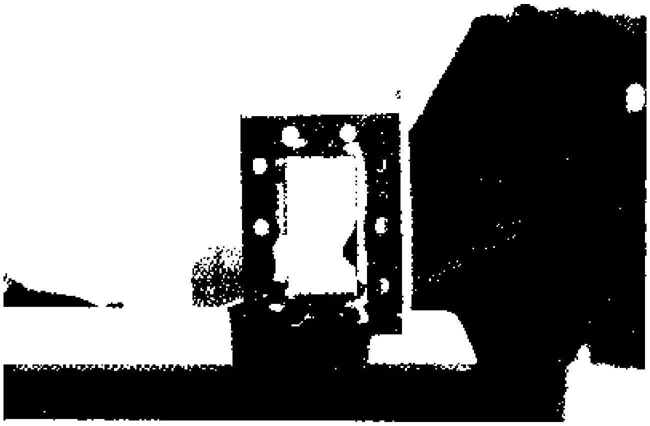
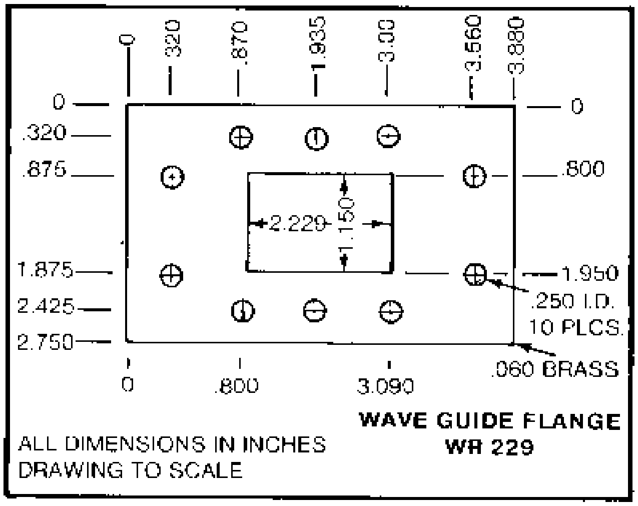


PHOTO 17.4

expect significant improvement by purchasing the Chaparral feedhorn. End commercial!

Figures 17.2 and 17.3 show all the dimensions for the feedhorn and the mating flange that bolts up to your low noise amplifier. Whatever material you elect to use, make sure you can solder to it. Cut out the pieces of material to the dimensions shown. Stand them up one at a time at right angles to each and run a solder beat down the seam. Be sure to keep the 8 inch pieces opposite each other and the same for the 7 inch pieces. The dimensions of the wide opening are not too critical but the dimensions of the small opening are critical because they have to fit the LNA flange. If you use P.C. board material for the flange, be sure to solder brass shim stock all around the outside and inside of the flange to join both sides of the material. If you use a solid piece of metal for the flange you won't have to do this.

Cut the flange out to the dimensions shown and solder it onto the horn you have just built. Make sure the flange is put on straight as possible. If you would like, you may lay your LNA, flange down, on whatever material you elect to use and trace



ALL DIMENSIONS IN INCHES
DRAWING TO SCALE

WAVE GUIDE FLANGE
WR 229

FIGURE 17.3

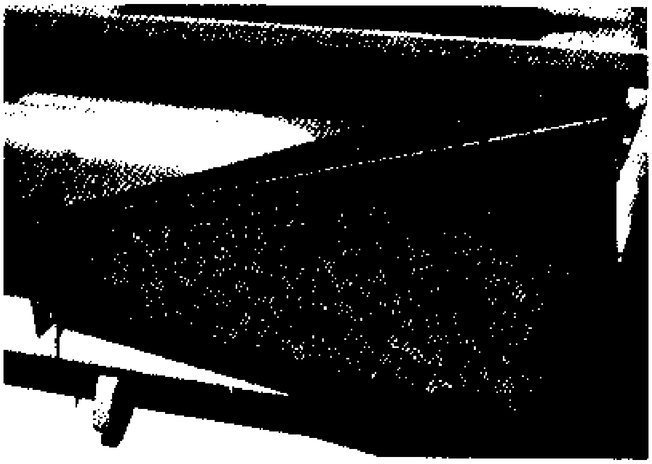


PHOTO 17.5

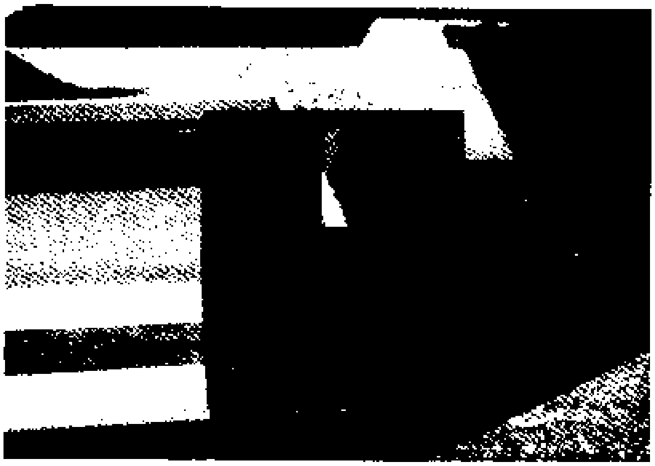


PHOTO 17.6

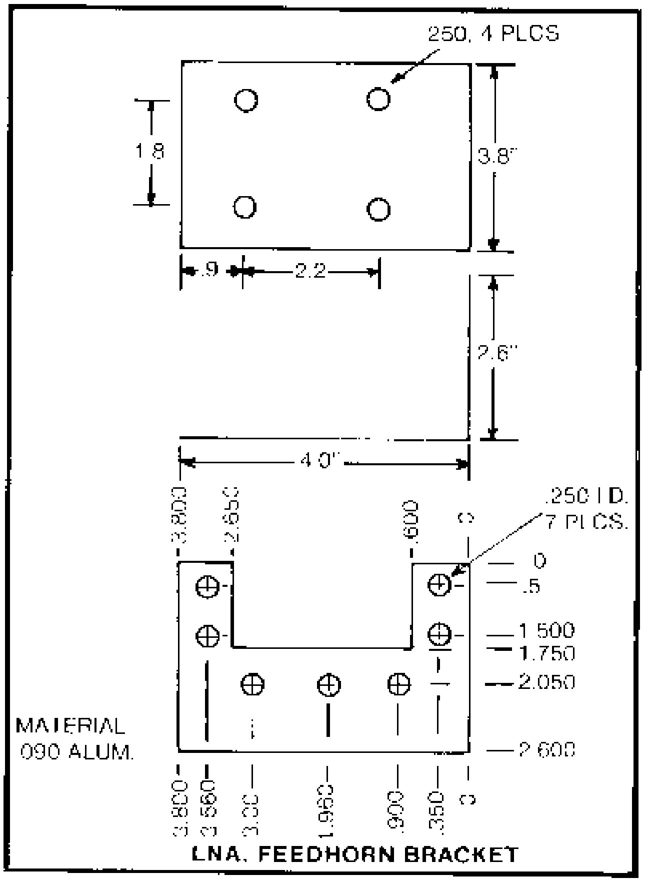


FIGURE 17.8

around its flange. This will be quicker than laying out the whole flange from scratch. If you don't have your LNA yet then I guess you will have to follow the drawing. Photos 17.4, 17.5, 17.6 are for reference as you build your feedhorn.

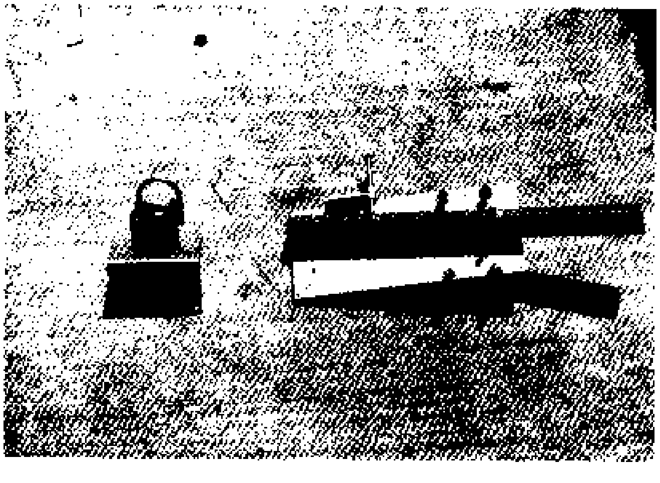


PHOTO 17.7

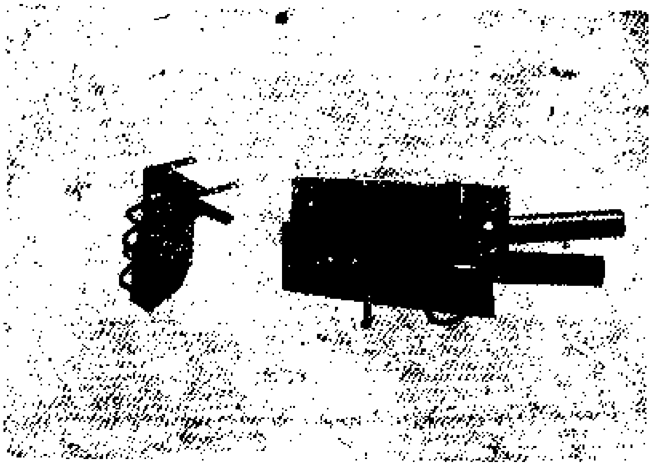


PHOTO 17.7A

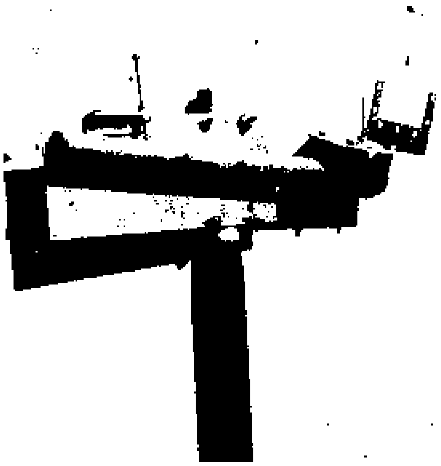


PHOTO 17.9

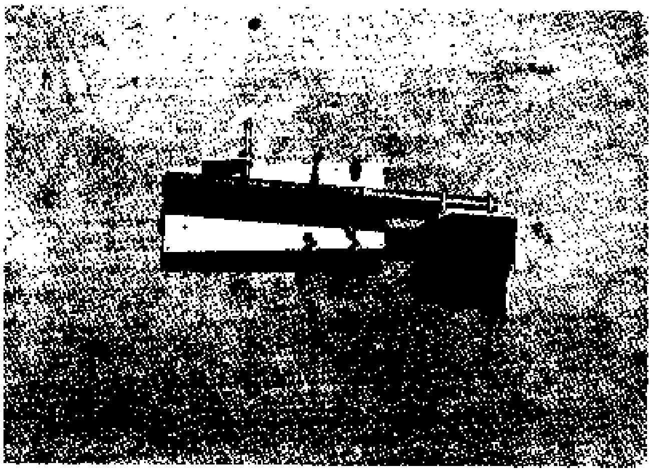


PHOTO 17.10

The next piece to be built will be the LNA and feedhorn mounting bracket. Photo 17.7, 17.7A and figure 17.8 show the dimensions for this part. The purpose of this piece is to hold the LNA and the feedhorn in the correct position during operation. As can be seen in the photo, the bracket is held to the 1½ inch pipe by ¼-20 U-bolts of the same size. The bracket has to have the same bolt pattern as the LNA and feedhorn so take care as you cut the bracket out. This bracket is totally non-critical as long as the LNA can bolt up to it. Feel free to improvise when building the parts in this section. I do not have the corner on the good ideas market: your way will probably be better than mine.

The next part you need to build will be the pole bracket. The purpose of this piece is to hold the pipe that the LNA bracket is bolted to, and allow the whole assembly to be rotated up and down to get the correct angle for the focal point and rotated for polarization. Photo 17.9 shows this best. The screw at right angles to the pipe sets the angle of the feedhorn in relationship

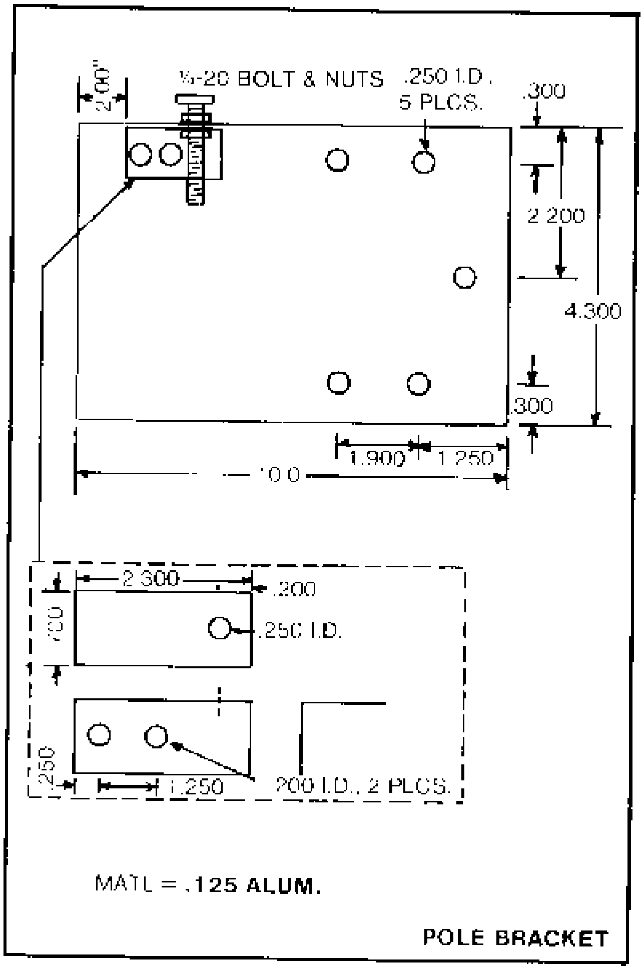


FIGURE 17.11

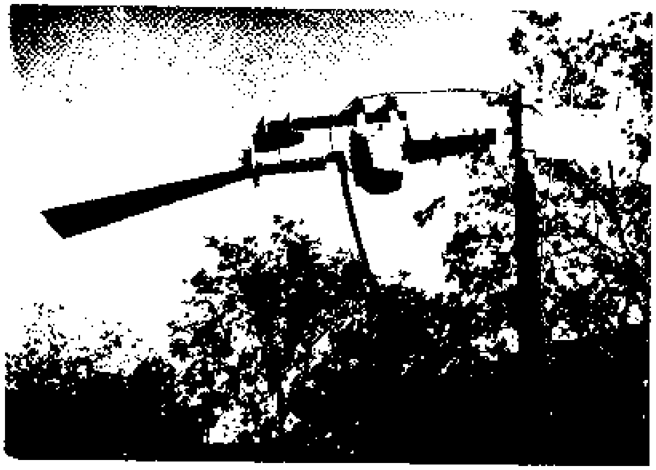


PHOTO 17.13

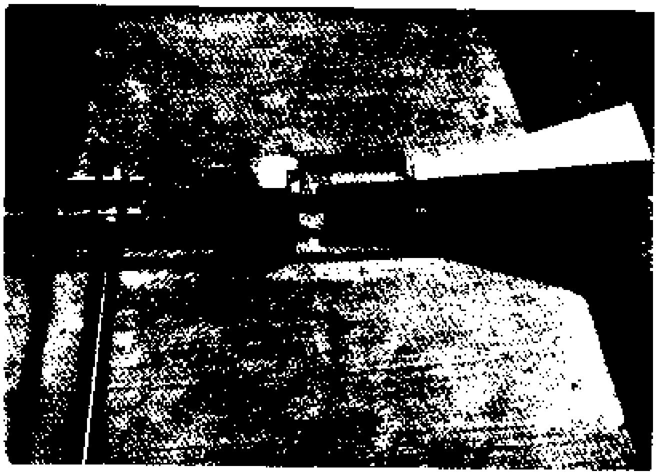


PHOTO 17.12

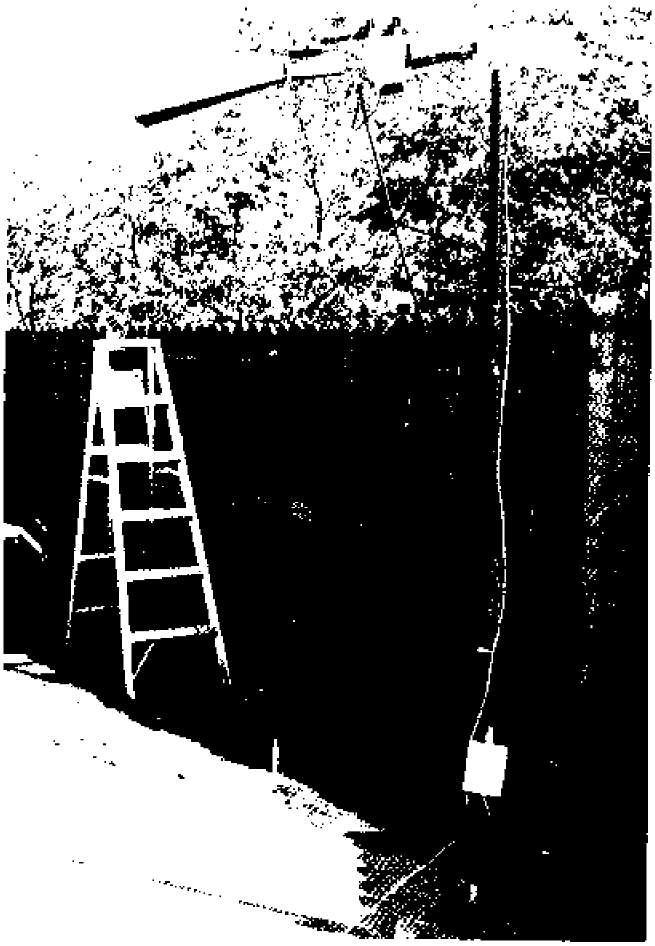


PHOTO 17.14

to the antenna. The LNA bracket can be rotated on the pipe for polarization. Photo 17.10 and figure 17.11 give the dimensions for the pole bracket. The ¼-20, 1 ½ inch U-bolts are used again to hold this assembly to the 1 ½ inch O.D. pole. The one ¼-20 bolt is used to hold the pipe the LNA bracket is bolted to, onto the pole bracket. This assembly is straight forward and I am not going to go into a lot of detail on how to build it. By now you are an expert on the art of making something out of nothing.

As you know, there will be a need to rotate the feedhorn assembly in order to receive all the transponders on the different satellites. There are 12 transponders on vertical polarization and 12 on horizontal polarization. You can go outside to do this by and hand or you can incorporate this feature into your feedhorn assembly. Photo 17.12 shows how I solved this problem. You will notice that the rotor is turned around and the end that normally stays put is now moving. This is because the feedhorn bracket is offset and needs to be moved in an arc to keep the feedhorn in the focal point. This may be hard to visualize but if you rotate the

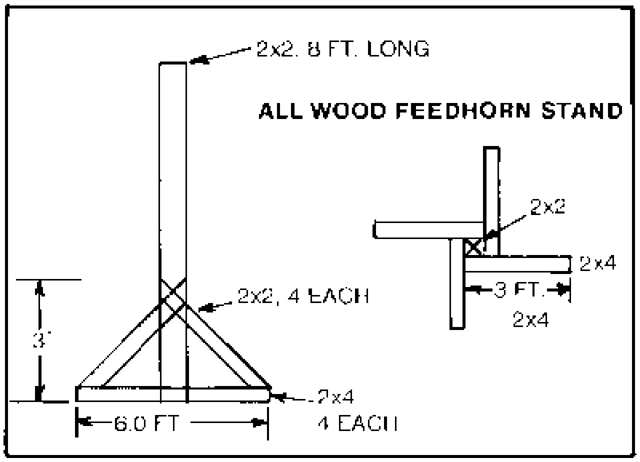


FIGURE 17.16

LNA bracket while holding the pipe it is bolted to, you will see the problem. The nice thing about this system is that this rotor is the cheapest kind because it is off-set. You will have to be careful to keep all the dimensions of the LNA bracket close to what I show or the rotor system will not rotate the LNA about its center. The next 3 photos show the complete system installed and running (17.13, 17.14, 17.15.) The concrete stand you see holding up the 8 foot, 1 ½ inch O.D. pole, everything is bolted to, is really an umbrella stand sold in most hardware stores. It accepts a pipe with an 1 ½ inch O.D. and cost $13.95 in my area. If you can't find one or don't want to buy one, I have a design for a cheap pole system. Figure 17.16 shows this design. I have not actually built this stand but I believe it should do the same thing as the umbrella stand.

Photo 17 17 shows a LNA bracket I had welded. As can be seen, this bracket eliminates the need to worry about the feedhorn system being off-center. I now use this bracket on my antenna system with a different rotor for polarization control. There was nothing wrong with the first system but I just came up with a better idea. Well, it's time to see if all this collection of junk will really give good video from 22,300 miles out in space.

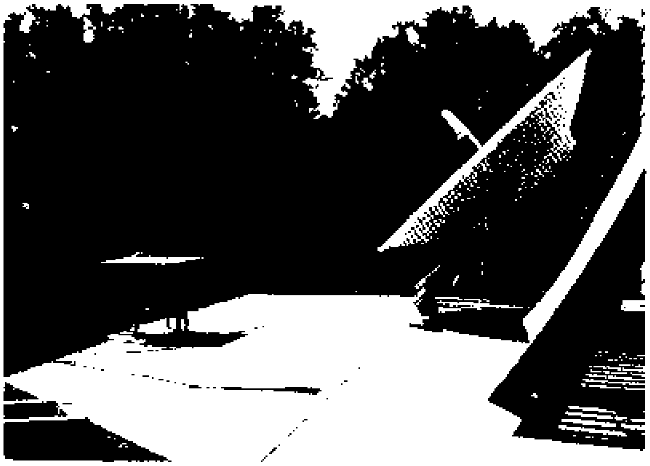


PHOTO 17.15

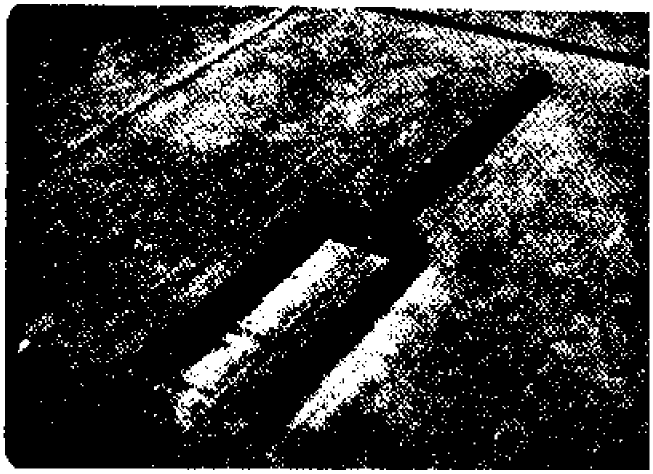


PHOTO 17.17

18.0) FIND THE SATELLITE, FIRST PICTURES!!!

For this section I will make some basic assumptions. 1) Your LNA is known to work. 2) Your receiver is known to work and is sitting on a channel. Your receiver should have soem sort of signal strength meter so you can peak the feedhorn for maximum signal. This way all we are trying to do is find the satellite not trouble shoot the rest of the electronics. The best way to test the LNA and receiver is to put them on an already operating antenna. If you have a continously tunable receiver you should leave it tuned to transponder 7 when you leave wherever you went to test the system. Have no fear, you can find the satellite without having tested the electronics; however, you will have more variables than some of the rest of us. This just means that if you look for the satellite for a couple of hours and have no luck, it might not be you. Your receiver or LNA could be letting you down.

Set your focal point structure up as shown in the last section. Rotate the LNA and feedhorn such that as you stand behind the LNA the broad side of the LNA is rotated clockwise by the number of degrees shown in section 3 under polarization for your local area, or close to you. The easiest way to see this is to think of a clock face, where zero (0) degrees is the same as 12:00and 90 degrees is at 3:00. Set the focal point structure in front of your antenna at about the 15 foot point. The feedhorn should be set above the ground by the amount shown in section 3 for your look angle is 46 degrees to Satcom 3R and my antenna was set at 27 degrees. This made my feedhorn 7 feet above the ground.

The most efficient way to look for a satellite is to have all the electronics out at the focal point area where you can see the TV yourself. Assemble all your equipment at the antenna. If you were not able to set your receiver to a known channel, you will need a friend to tune the receiver back and forth as you sweep the feedhorn structure around the antenna. On my first attempt at finding a satellite with a spherical antenna, I set everything as indicated, turned on the electronics and there was nothing there. Bet you thought I was going to tell you I found the satellite that easy. I spent about 10 minutes waving the feedhorn around and then I saw a picture flutter by. The problem gets a lot harder if your antenna is not set face on to the satellite. It is hard to visualize where you should stand if the satellite is offset from the front of the antenna. I will assure you at this time that there is a satellite up there where I say it is. It didn't crash into the ocean yet. Keep trying.

If you spend four hours looking with no luck, stop and ask yourself what you are doing wrong or what isn't working. It's not

PHOTO 18.1 *FIRST PICTURES!!*

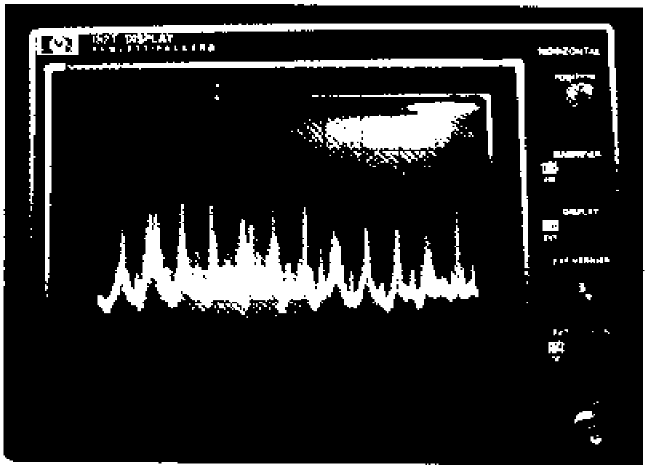


PHOTO 18.2

This is what a full satellite looks like. If you count them, you will find there are 12 signals. If you look real close, you can see a signal in between the main signals. These are the channels on the other polarization.

PHOTO 18.4

that hard to find the satellite. If you are using a receiver with a modulator, make sure your TV set is tuned to the right channel for that modulator. Don't laugh, nearly every satellite show I attend I see somebody trying to find the satellite with the TV and modulator on different channels, and these are supposed to be "experts".

Once you have a picture of any sort, peak the signal meter by moving the feedhorn around about an inch or two. The point where the signal is should be very small. On my antenna, if I moved the feedhorn left or right more than an inch, the signal would fade away. You should try moving forwards and backwards about a foot to make sure you are at the correct spot for the focal point. You can move forwards and backwards a lot before the picture degrades as this is really a focal line. I have spent hours squeezing the last tenth out of a dB out of an antenna. Do it, it pays off in good looking pictures. If you don't have a signal strength meter, then after you have acquired first pictures, tune your receiver to transponder 1. That is the weakest transponder on F3. Then you can move the feedhorn around for the best picture.

I don't care how many times I set up a satellite system, the first time I get pictures I am always impressed with the technology. Imagine, pictures from 22,300 miles away. Doesn't that impress you? Well anyway, photos 18.1 and 18.2 show my equipment and my first pictures. The receiver to the left is a Scientific Atlanta 6602 receiver and the TV is a N.E.C. color monitor. The box to the right is a Hewlett Packard Spectrum analyzer. Some of the experts out there are probably crying foul because anybody can find the satellite with a spectrum analyzer. They're right, I see no need to work any harder than necessary. I will use any and all test equipment to be more efficient with my time. I have spent a lot of time searching for satellites when all I had was a compass and a light bulb. I used a different receiver for all the subjective testing presented in the next sections. The S.A. receiver had fixed tuning so I just set it on transponder 7 and looked for a picture. I have included some pictures of the TV set on different transponders. These kind of pictures generally don't show what I like but they're better than nothing.

PHOTO 18.3

PHOTO 18.5

19.0) BOTTOM LINE! HOW WELL DOES THE ANTENNA WORK?

When you have squeezed the last drop of signal out of the antenna, it's time to take everything inside, get something cold or hot to drink and sit down and see how well the system works. The quality of the pictures is dependent upon the whole system - antenna, feedhorn, LNA and receiver. The most important part is the antenna. I have seen lousey receivers look great when hooked up to a well built antenna.

Using a Gillaspie and Associates Model 7600A receiver and a Dexcel 120 degree LNA. I noted the following subjective evaluation of the received picture. All the veritcal transponders on F3 , i.e. 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, and 23 were absolutely sparkle free; there was no noise or anything else - just beautiful pictures. That's when I knew I could start writing this manual, the antenna worked!! I then rotated the feedhorn 90 degrees so I could receive the horizontal transponders, i.e. 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22 and 24. The horizontal transponders are generally weaker than the vertical transponders here in Northern California by about .8 dB. I noted all transponders were also sparkle free. At the time I was testing the antenna, transponder 22 had color bars and I saw some slight noise in the saturated orange, but no sparkles. Color bars are the toughest test a system has to pass as they have the widest deviation and require a good carrier to noise to look good. That told me the antenna was doing a good job even before I broke out the antenna test gear.

After I was satisfied the antenna was working well enough to continue with this manual, I then tested each transponder as to the received carrier-to-noise ratio. This would tell me how well the antenna was working in a more scientific manner. Until I got to this point, I wasn't sure this spherical design was any good. I thought it might be, but you never know until you build it. If I had turned it on, using all my test gear to get the best signal, and the video didn't look good, what chance did anybody else have? As a side note, and this is called a digression, after I had convinced myself the antenna was okay, I removed all the expensive test gear and dragged out my Gillaspie 7600A receiver. I moved the focal point structure out of its position and lowered the feedhorn and started all over again. I was able to get the same great pictures just using the signal meter on the 7600A receiver, so I knew anybody else could do the same thing.

The term carrier-to-noise ratio defines how much signal I have versus how much noise there is. It is a way of qualifying how good a picture you will get by saying what the C/N in dB is. The following chart is sort of an industry standard.

CN (dB)	Video Picture Quality
5.0	extremely noisy, tearing, sparkles.
6.0	a little better, you might watch it!
7.0	watchable, but lots of sparkles.
8.0	at rec. threshold, a few sparkles.
9.0	very good picture, few sparkles on saturated colors.
10.0	video tape quality, no sparkles.
11.0	C.A.T.V. quality.
12.0	C.A.T.V. quality with margin.
13.0	broadcast quality.
14.0	broadcast quality with margin.

The following list shows the as-tested C/N ratios of my homebuilt 12 foot spherical antenna here in California.

Transponder	C/N(dB)
1	8.5
2	11.2
3	12.0
4	10.3
5	10.6
6	10.9
7	11.8
8	10.6
9	11.1
10	12.2
11	12.4
12	10.8
13	10.5
14	11.4
15	9.2
16	11.1
17	10.2
18	not tested
19	11.2
20	11.8
21	10.5
22	12.0
23	13.2
24	12.0

I would like to comment on some of these numbers. First, there was no carrier present on transponder 18 at the time I was testing the antenna. Transponder 15 was abnormally low when tested. I don't know why it was so weak at that time. The quality of the received signal is very much dependent upon the uplink that services that transponders keeping the power where it should be. I have tested other antennas multiple times and I have noted a change of about 1.0 dB from one day to the next. If you would like to convert these C/N to S/N just add 38 dB to my numbers and you will have S/N.

20.0) WHAT I WOULD DO DIFFERENT? OR HOW I SCREWED UP.

The antenna has been up and running now for 60 days - long enough to have been rained on 3 times, have a midair with a pigeon, and, if looks could destroy, the neighbors have frowned at it enough to turn it into firewood. I have been sleeping light since I built it, listening for the sounds of a chain saw!

In all construction projects there comes a time when you see you could have done things differently, or better. Not me, this creation is perfect. Only kidding!!!

The first item that comes to mind is the diagonal braces. I allowed them to push the frame sides out which made me have to add patches to extend the ribs. Then on the other side of the brace, the frame was too small so I had to cut the ribs down by ¼ inch. No big problem, just a pain you know where.

The next area in need of creative planning was the alignment of the four sides that make up the antenna frame. When I got to the end I found the left side was ¼ of an inch too high so I had to very carefully plane it down. Another two hours shot.

The last screw up was my lack of planning on how big my back yard was. I built the 12-foot stand then couldn't get far enough back from the antenna to find the focal point. If this had been my first spherical antenna, I might still be looking for the satellite. Plan ahead!!!

One of my first spherical antennas was built out of steel. The problem with that was when it got hot the curve changed. The antenna worked best at night, which, come to think of it, was the right time to work. That is one of the reasons I built this one out of wood. So far, it seems to work the same day or night. About the only thing I can think to change, would be to run a 2x4 along the bottom side the antenna is resting on, to distribute the load better. This is especially true if you are going to install this antenna on an uneven surface. The 2x4 would keep the loads from cracking the 1"x18"x12' due to uneven pressures. On a cement surface, I don't think this will be a problem.

GOOD LUCK WITH YOUR SYSTEM!!

21.0 SO YOU WANT TO BUILD A BIGGER ANTENNA.

I am including this section so that if you live in a region that has a poor satellite footprint you can build an antenna that is larger than 12 feet. I have not built any of these antennas. I have enough trouble with the neighbors as it is with my 12 footer.

The focal point to diameter (f/D) on this antenna is 1.25. We want to maintain this f/D on all the rest of the larger antennas. This means that we will just take the ratio of the 12 foot antenna to the antenna in question to come up with the larger antenna's dimensions. Figure 21.1 shows the geometry of the 12 foot model as built in this manual. The following table will give you the needed dimensions for the bigger antennas.

Dia. (ft.)	Ratio	Focal Point (ft.)	Radius (ft.)
12	0	15.0	30
14	1.1667	17.5	35
16	1.3333	20.0	40
18	1.5000	22.5	45
20	1.6667	25.0	50

If you want to build a size not shown, just divide the size you want by 12, this will give you a ratio. Then multiply the size you want by this number to come up with the focal point and radius. As far as the braces and antenna stand are concerned, you can multiply the 12 foot dimensions by the scale factor (ratio) you came up with for your size. I would suggest keeping the rib spacing at 8 inches as that is the best dimension for holding the curve and a good width for the screen mesh. Once you go past 14 feet, I would suggest making the antenna frame out of 2-inch thick by 18 inch wide wood for better strength. The only other change I can think of is to go to two midboard braces instead of one. In other words, divide the rib length by 3 and put a brace a third the way along the rib. This is to keep the ribs from moving around and stretching the screen mesh. If you build an antenna bigger than 20 feet, please write and tell me all about it and include a photo if possible.

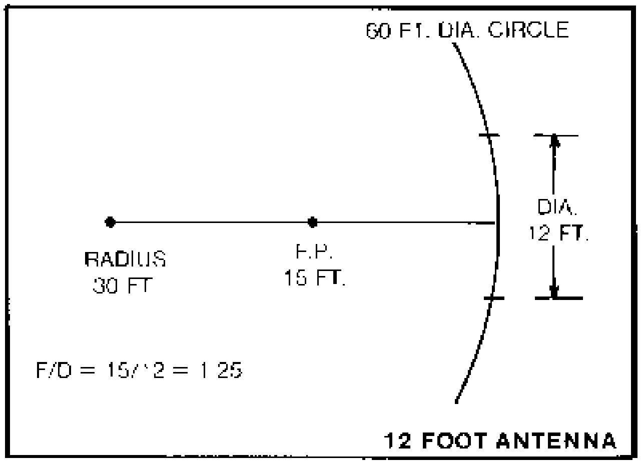


FIGURE 21.1

22.0) MATHEMATICS (BLAH!!)

It is not necessary to read this section in order to build a perfectly working antenna. If you are looking for some light reading while in the out-house, this isn't it. I even considered leaving this section out. It's a pain to write so that all the experts don't nail me to the wall. I don't suppose you'll trust me for it? Oh well. I guess you paid for the manual, you might as well get your money's worth.

(**Note:** When you see a number followed by a star (*) and a 2, this means raise that number to the second power.)

WOE BE ON THEE, WHO VENTURES PAST THIS POINT!!!

Antenna Gain

The first formula that seems reasonable to bring up is antenna gain. This is the formula that all the antenna manufacturers have figured out. They compute the gain of a piece of fiberglass that used to be a boat and sell it by the numbers.

$$GAIN = 10\log(.55\,\frac{4\pi A}{\lambda^2})$$

Where .55 is because the feed system is not perfect.
A = area of reflecting surface, in inches. (A = π R*2)
Pi = π = 3.1415
λ = lambda, wavelength at this freq. (3950MHz)

Example: Our 12 foot spherical antenna
Because of poor feed characteristics, we are not able to feed the whole reflective surface properly. We will treat the square antenna as if it were a 12 foot round antenna. First the square area is found.

A = (πR*2)
= (3.1415 x (144"/2)*2)
= (3.1415 x (72)*2)
= (3.1415 x 5184)
= 16286.02 Sq. inches.

λ = 2.989 inches (λ ft. = 984/f in MHz)

So:
Gain = 10 log (.55(12.566 x 16286 / (2.989 x 2.989)))
10 log (.55(204649.88/8.9361))
10 log (.55(22901.5))
10 log (12595.8)
10 (4.10)
= 41.0 dB.

So at 3.950 GHz your antenna has 41.0 dB of gain. (If you did everything right.)

Gain over temperature, G/T.

The next formula of interest is Gain over temperature, G/T. This is a figure of merit assigned to an antenna. It depends somewhat on the elevation angle because of atmospheric absorption noise contribution. LNA effective temperature, about 120 degrees K.

and the antenna gain. As the formula implies G/T is a comparison of the antenna gain to the antenna noise figure. We know the gain as we just computed it. The antenna noise figure is a function how low on the horizon the antenna is looking. The lower we look the more earth noise we see and the more atmosphere the antenna has to shoot thorugh.

This number will be different for every antenna because of the location and the LNA temperature. As the antenna looks lower and lower on the horizon, the antenna temperature will rise. The following chart shows what a spherical antenna noise contribution will be for different look angles. I measured the noise temperature on a 12 foot spherical to develop these numbers.

Antenna Look Angle	**Antenna Noise**
5 degrees	73 degrees K
10 degrees	62 degrees K.
15 degrees	55 degrees K.
20 degrees	51 degrees K
30 degrees	47 degrees K
40 degrees	45 degrees K
50 degrees	43 degrees K.

The formula for gain over temperature is:
G/T = Ag - 10 log(At+Lnat)
Where Ag = antenna gain. (41.0 dB)
At = antenna temp. at look angle. (50 deg.K.'Ca'if.)
Lnat = LNA temperature. (120 deg.K)

So.
G/T = 41.0 - 10log (50 + 120)
= 41.0 - 10log (170)
= 41.0 - 10(2.23)
= 41.0 - 22.30
= 18.7 dB/K.

Carrier to Noise Ratio, C/N.

The next formula we shall consider is carrier-to-noise ratio. This one as noted in the last section gives you some idea how well the system will perform

The long form for C/N is:
C/N = G/T + Eirp - L(d) - L(md) - K - 10 log (B)
Where = G/T already computed (18.7)
– Eirp, taken off the foot print map for your area. for example. (34 dB)
– L(d), path loss Sat. to you (196.3 dB)

If you don't want to use my path loss number go to the section on path loss and compute one for your area.
= L(md), ant pointing error, rain, etc (.5 dB)
– K, Boltzmanns constant (-228.6 dBw/K)
= B, receiver bandwidth. Assumed to be 30 MHz.

So
C/N = 18.7 + 34 - 196.3 - .5 - (-228.6) - 10 log (30 MHz)
= 18.7 + 34 - 196.3 - .5 (-228.6) - 74.77
= 52.7 - 196.8 + 228.6 - 74.77
= 52.7 + 31.8 - 74.77
= 84.50 - 74.77
= 9.73 dB

The short form for C/N is:
C/N = G/T + Eirp - 42.9
= 18.7 + 34 - 42.9
= 52.7 - 42.9
= 9.8 dB. Refer to the preceeding section for detailed chart on C/N and picture quality.

Beam Width.

If you think of this antenna as a transmitting antenna the energy that we transmit will occupy so many degrees of space at 22,300 miles away. The number of degrees space the antenna "sees" is called beam width. The bigger the antenna or the higher the frequency the smaller this number will be.

B = (1.22)(λ) / D (57.3)
Where D – diameter of antenna in inches
D = 12 feet x 12" = 144"
λ = 2.9" for 3950 MHz
The constant 57.3 converts radians to degrees

B = ((1.22) (2.9) / 144) (57.3)
= (3.54/144) (57.3)
= .0246 (57.3)
= 1.40 degrees.

Path Loss.

If you are really trying to split hairs, you can compute the distance from the satellite to your antenna and then figure out the path loss exactly. This number is used in the C/N equation. This number can vary +/- ½ dB depending on whether you are on one end of the country or the other. It can also vary +/- 1.0 dB as a function of the frequency of the transponder used.

Path loss = 37 + 20log (F) + 20log (D).
Where 37 is a constant.
: F is the frequency in use (MHz)
: D is distance to satellite in miles

Path loss. Satcom 3 to San Francisco, at 3950 MHz and 23226 mi is:

Path loss = 37 + 20log (3950) + 20log (23226)
= 37 + 20(3.60) + 20(4.37)
= 37 + 72.0 + 87.4.
= 196.25 dB
Path loss for other frequencies, same distance.
3700 MHz = 195.7 dB
3950 MHz = 196.25 dB.
4200 MHz = 196.8 dB.

Look Angle.

This next section will cover computing your look angle the hard way. As part of the cost of this manual, I will be happy to have my computer grind out a look angle chart for your local area. All you have to do is send me a self addressed stamped envelope with your longitude and latitude and I will send you back a chart that will give the look angles for all the satellites. If you want to work out your own look angles then you will need a pocket calculator capable of triqnometric functions. You will need the following data:

Station Longitude
Station Latitude
Satellite Longitude.

You can get the satellite longitude from section 3 look angle charts. They are under the heading "node". Your station longitude and latitude can be obtained for an atlas or try hanging out at your local airport most pilots can give you that information unless they are lost.

First some definitions:

Arccos = Arc Cosine Trig. function.
Cos = Cosine trig. function
Sin = Sine trig. function.
Arctan = Arc Tangent trig. function.
Tan = tangent trig. function.
Sqrt = square root.
Stalong = station longitude + for East, - for West.
Stalat = station latitude. + for northern, - for southern.
Satlong = satellite longitude. +for east. - for West

First find the great circle angle between station and satellite. Satcom 3R = 131 degrees longitude. San Jose. CA = 121.55.6,00 west longitude. 37.21.7,00 north latitude. I first have to convert the degrees, minutes. seconds to decimal by dividing by 60. That changes them to 121.9267 W, 37.3617 N.

GCIR = Arccos (cos(stalong-satlong)(cos(stalat)).
= Arccos (cos(-121.9267-(-131))(cos(37.3617)).
= Arccos (cos(9.0733)(.7948)).
= Arccos (.7849).
= 38.2918 degrees. If this number is greater than 81.3 degrees you can't see the satellite.

Since the number is less than 81.3 we can continue. The next formula is for Azimuth of the station from true north. If your station is in the northern hemisphere, then use this formula:

Az = 180+ Arctan(tan(stalong-satlong)/sin(stalat).
Az = 180 + Arctan(tan(-121.9267-(-131)/sin(37.3617).
= 180+ Arctan(tan 9.073/.6068)
= 180 + Arctan (.2632)
= 180 + 14.74
= 194.74 degrees, true.

If your station is in the southern hemisphere then use this formula:

Az = Arctan(tan(stalong-satlong)/sin(stalat)

The next formula to work out is the distance to the satellite. We will need this to compute the elevation of the satellite above the horizon. You can't say I didn't warn you!

RNG = Sqrt(1818590000 - 536950000 cos (GCIR).
= Sqrt (1818590000 - 536950000 cos (38.2918)
= Sqrt (1818590000 - 421433295.7.
= Sqrt (1397156704)
= 37378.56 KM. (to convert to miles divide by 1.609).
= 23230 Miles.

Finally, we get to the last formula. elevation of the satellite above the horizon.

EL = -90+ Arccos ((RNG^2 + (-1737462000)/12734RNG).
= -90 + Arccos ((37378.56^2 + (-1737462000)/12734(37378.56)
= -90 + Arccos ((1397156748 + (1737462000)/475978583)
= -90 + Arccos (.7150)
= -90 + 44.36
= 45.64 degrees.

Great circle = 38.2918 degrees
Azimuth = 194.74 degrees.
Range = 37378.56KM or 23230 Mi
Elevation = 45.64 degrees.

I have given you an example of each of the given formulas. If you go look at section three, under San Jose and for Satcom 3R, you will find that these computed values are very close to the computer's guess. I would suggest working out a few positions where you know the answer, just to check your calculator of course!

NOTICE TO USERS OF THE GUSTAFSON SPHERICAL ANTENNA MANUAL:

While this manual is intended to be a complete guide to construction of a Gustafson Spherical Antenna, there is no way that such a manual can pre-guess every builder's questions nor his particular aptitude for such a project. For this reason, the manual's author, Mike L. Gustafson, makes himself available for "mail-order consultation".

If you wish to seek advice on this antenna, you can do so for a fee of only $10 (check or money order to be made out to Mike L. Gustafson). Sorry, no telephone consultations. Send your letter with fee to the following address:

Mr. Mike L. Gustafson
1606 Capitancillos Drive
San Jose. California 95120

Please understand that this consulting/advisory service extends only to yourself as the original purchaser of this manual and does not extend to others who may "share" the manual.